INSTALLATION RESTORATION PROGRAM

FINAL

Remedial Investigation Report

May 1997

144TH FIGHTER WING
CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL, FRESNO, CALIFORNIA

HAZWRAP SUPPORT CONTRACTOR OFFICE
Oak Ridge, Tennessee 37831
Operated by MARTIN MARIETTA ENERGY SYSTEMS, INC.
For the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-840R21400

Final

Remedial Investigation Report for the 144th Fighter Wing California Air National Guard Fresno Air Terminal, Fresno, California

Submitted To:

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U.S. Department of Energy
Contract DE-AC05-84OR21400

May 1997

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	MAY 1997	REMEDIAL INVESTIGATION REPORT

4. TITLE AND SUBTITLE
REMEDIAL INVESTIGATION REPORT
144TH FIGHTER WING, CALIFORNIA AIR NATIONAL GUARD

5. FUNDING NUMBERS

6. AUTHOR(S)
IT CORPORATION

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
HAZARDOUS WASTE REMEDIAL ACTION PROGRAM
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
P.O. BOX 2002
OAK RIDGE, TN 37832-6501

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AIR NATIONAL GUARD
INSTALLATION RESTORATION PROGRAM
3500 FETCHET AVENUE
ANDREWS AIR FORCE BASE, MD 20762

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE. DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
Remedial Investigation Report documenting the results of soil and groundwater samples obtained during the 1992 field effort. This report covers Site 5 - Base Collection Pond. Based on the data the Site was recommended for further action under the IRP. The State concurred with this recommendation.

14. SUBJECT TERMS
Installation Restoration Program, Air National Guard, Fresno Air National Guard Base

15. NUMBER OF PAGES
230

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	NON

Standard Form 298 (Rev. 2-89) (EG)
Prescribed by ANSI Std. 239.18
Designed using Perform Pro, WHS/DIOR, Oct 94

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List of Acronyms

ANG	Air National Guard
ANGRC	Air National Guard Readiness Center
ARAR	applicable or relevant and appropriate requirements
BCP	Base Collection Pond
bgs	below ground surface
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
cm/s	centimeters per second
COC	chemical of concern
COPC	chemical of potential concern
CWA	Clean Water Act
DCA	dichloroethane
DCE	dichloroethene
DCP	dichloropropane
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DTSC	California Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
ERM	ERM-West, Inc.
°F	degrees Fahrenheit
FAT	Fresno Air Terminal
FS	feasibility study
ft^2/day	square feet per day
FTA	Fire Training Area
FW	Fighter Wing
GC	gas chromatograph
gpm	gallons per minute
HAZWRAP	Hazardous Waste Remedial Action Program
HI	hazard index
HMTC	Hazardous Materials Technical Center
IAG	interagency agreement
ID	inside diameter

IDW	investigation-derived waste
IRP	Installation Restoration Program
IT	IT Corporation
k_{oc}	organic carbon partition coefficient
k_{ow}	octanol-water partition coefficient
LAAM BN	Light Antiaircraft Motorized Battalion
MCL	maximum contaminant level
MCLG	maximum concentration limits goal
μg/kg	micrograms per kilogram
μg/L	micrograms per liter
mL	milliliter
msl	mean seal level
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NTU	nephelometric turbidity units
OD	outside diameter
OSHA	Occupational Safety and Health Administration
PA	preliminary assessment
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyls
PCE	tetrachloroethene
POL	petroleum, oil, and lubricants
ppb	parts per billion
ppm	parts per million
PVC	polyvinyl chloride
QC	quality control
RI	remedial investigation
RME	reasonable maximum exposure
ROD	record of decision
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SI	site investigation

List of Acronyms *(Continued)*

SOV	soil organic vapor
SVOC	semivolatile organic compound
TBC	to be considered
TCE	trichloroethene
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbon, diesel
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USMC	U.S. Marine Corps
VOC	volatile organic compound
yd^3	cubic yards

Executive Summary

A remedial investigation (RI) of the California Air National Guard (ANG) Base in Fresno, California (the Base) has been conducted since the completion of the site investigation (SI) in 1991. The Base lies within the boundaries of the Fresno Air Terminal. Environmental activities at the Base have followed the Air National Guard Readiness Center's Installation Restoration Program (IRP) for identifying, characterizing, managing, and remediating sites with potential surface and subsurface contamination by past base use or disposal practices. The SI consisted of characterizing four sites identified in a preliminary assessment as potential sources of environmental contamination. As a result of information gained from the SI, a fifth site (Site 5), the Base Collection Pond (BCP), was identified as a potential contributor to groundwater contamination beneath the Base. Following recommendations from the SI, the investigation program moved into a RI for characterizing subsurface conditions in and around Site 5-BCP. The four SI sites were not carried into the RI, and so are not discussed in this document. Investigation data collected subsequent to the SI at these four sites is presented in the draft Supplemental SI report prepared in 1996 by IT Corporation (IT). Information concerning the disposition of SI sites is detailed in the Supplemental SI report.

Concurrent with the RI, groundwater contamination by trichloroethene (TCE) was identified in groundwater beneath the eastern portion of the Fresno Air Terminal in the vicinity of the Base as described in the 1992 Area 1 site inspection and 1994 engineering evaluation/cost analysis reports by ERM-West, Inc. Several Base perimeter monitoring wells were installed along the periphery of Base property during the SI to assess local groundwater conditions. These wells confirmed that groundwater flowing beneath Base property had been impacted by the regional TCE plume. However, tetrachloroethene (PCE) was detected only in groundwater samples collected at the downgradient edge of Base property. The objective of the RI was to determine if Site 5-BCP was the source of PCE groundwater contamination.

Based on an evaluation of data collected during the SI, the following activities were implemented:

- Quarterly groundwater sampling at the investigation sites and at the Base perimeter
- An RI at Site 5-BCP and across the western portion of the Base
- An initial deep aquifer investigation

- Aquifer/pumping tests and deep monitoring well groundwater sampling
- A baseline risk assessment of soil and groundwater at Site 5-BCP.

The Site 5-BCP RI was conducted from August through October 1992. Quarterly groundwater sampling was performed from June 1992 to April 1993. As a result of the Site 5-BCP investigation, the initial deep aquifer investigation was developed, and was conducted from October through December 1993. Following the evaluation of data from the deep aquifer investigation, pumping tests were conducted at the Base in March 1995.

The RI included a soil organic vapor survey in and around Site 5-BCP, drilling and sampling soil borings, performing soil screening analyses with a gas chromatograph, and installing and sampling monitoring wells. Data collected during the RI determined that Site 5-BCP was at one time the source of PCE contamination to groundwater. Concentrations of chlorinated organic compounds measured in Site 5 soil suggest that the BCP is not a continuing source area. Based on the findings of the RI, the State of California approved a request by the Base to perform construction activities at Site 5-BCP. As a part of a major Base construction project, the BCP was filled to grade with soil in preparation for building a fuel farm on the property by the year 2007. This activity will eliminate future infiltration to the deep soil in this area such that the future leaching potential of residual contaminants to groundwater is greatly reduced.

The baseline risk assessment concluded that exposure to soil at Site 5-BCP does not pose an unacceptable risk to human health or the environment. Exposure to groundwater downgradient of the Base and on the individual investigation sites also does not pose an unacceptable risk to potential receptors. However, exposure to groundwater upgradient of the Base perimeter does represent an unacceptable cancer risk, largely due to high concentrations of TCE. TCE contamination is a part of a regional TCE plume, unrelated to activities at the Base. The total risk from downgradient Base perimeter wells is less than the total risk from upgradient perimeter wells due to lower concentrations of chlorinated organics in downgradient wells.

Through the SI, quarterly groundwater sampling program, and RI, the lateral extent of groundwater contamination in the uppermost water-bearing zone was determined. An initial deep aquifer investigation was then designed and conducted to characterize the vertical extent of contamination associated with past Base use and/or disposal practices. Deep aquifer

investigation activities were conducted from October through December 1993 and included deep exploratory borings, groundwater sample screening, installation of a deep monitoring well network, and subsequent groundwater sampling and analysis.

The deep aquifer investigation found that TCE contamination in groundwater extends to depths of at least 250 feet below ground surface (bgs). PCE groundwater contamination, for which the Base is the identified source, was not detected below a depth of 130 feet bgs. Exploratory borings drilled during the deep aquifer investigation provided detailed information regarding subsurface lithology and allowed an initial environmental assessment of aquifer zones within the hydrogeologic setting beneath the Base.

Aquifer tests were conducted as a final step of the deep aquifer investigation to estimate aquifer properties and to assess possible interconnections with the uppermost water-bearing zone that would have an effect on the migration potential of PCE. Aquifer tests and related activities were performed in February and March 1995.

Groundwater samples collected during various investigation phases detected greater concentrations of PCE in downgradient samples than in on-Base samples. This indicates that PCE has migrated off of Base property and suggests that the majority of the mass of PCE in groundwater has already migrated downgradient of Base property.

Based on the results from each of the related phases of work conducted during the RI at the Base, the following recommendations are made:

- The vertical and lateral extent of PCE groundwater contamination should be further delineated downgradient of Base property. This would be more efficiently accomplished in conjunction with characterization studies associated with the regional TCE groundwater plume.

- On-Base groundwater sampling should be performed as part of the continuing regional groundwater investigation.

- Delay preparing a feasibility study until regional investigations of TCE groundwater contamination are completed. Combining the feasibility study and any future remedial actions for both TCE and PCE groundwater plumes offers the greatest efficiency of resource utilization.

1.0 Introduction

1.1 Purpose of Report

A remedial investigation (RI) at the California Air National Guard (ANG) Base in Fresno, California has been ongoing since the completion of the site investigation (SI) to characterize the horizontal and vertical extent of contamination in soil and groundwater beneath the Fresno ANG Base (the Base). This report documents the data collection and analysis phase of the RI, which includes characterization of soil and groundwater at Site 5, the Base Collection Pond (BCP), and characterization of groundwater as it enters and exits the Base. Investigation programs were designed to achieve the following objectives:

- Determine the presence of suspected contamination in the subsurface at Site 5-BCP.
- Determine the nature and horizontal and vertical extent of contamination.
- Assess trends in contaminant concentrations in site-specific and Basewide monitoring wells screened at the water table.
- Determine the nature and vertical extent of groundwater contamination associated with past Base activities.
- Supplement and refine the existing geologic, hydrogeologic, and geochemical data for the Base and surrounding areas of interest.

This document reports the results of field investigations and testing conducted during the RI. It also provides a brief history of investigations at the Base, provides the rationale for conducting each investigation phase, evaluates the data collected, reviews the extent of contamination, and presents conclusions on the nature and extent of contamination found.

1.2 Background

The National Guard Bureau, now referred to as the Air National Guard Readiness Center (ANGRC), through the Air Force Engineering and Services Center, has entered into an interagency agreement ([IAG] No. 1489-1489-A1) with the U.S. Department of Energy (DOE). Under this agreement, DOE provides technical assistance for implementing the ANGRC Installation Restoration Program (IRP) and related activities. The ANGRC has requested support in assessing the extent of suspected contamination at the Fresno ANG Base (Figure 1-1).

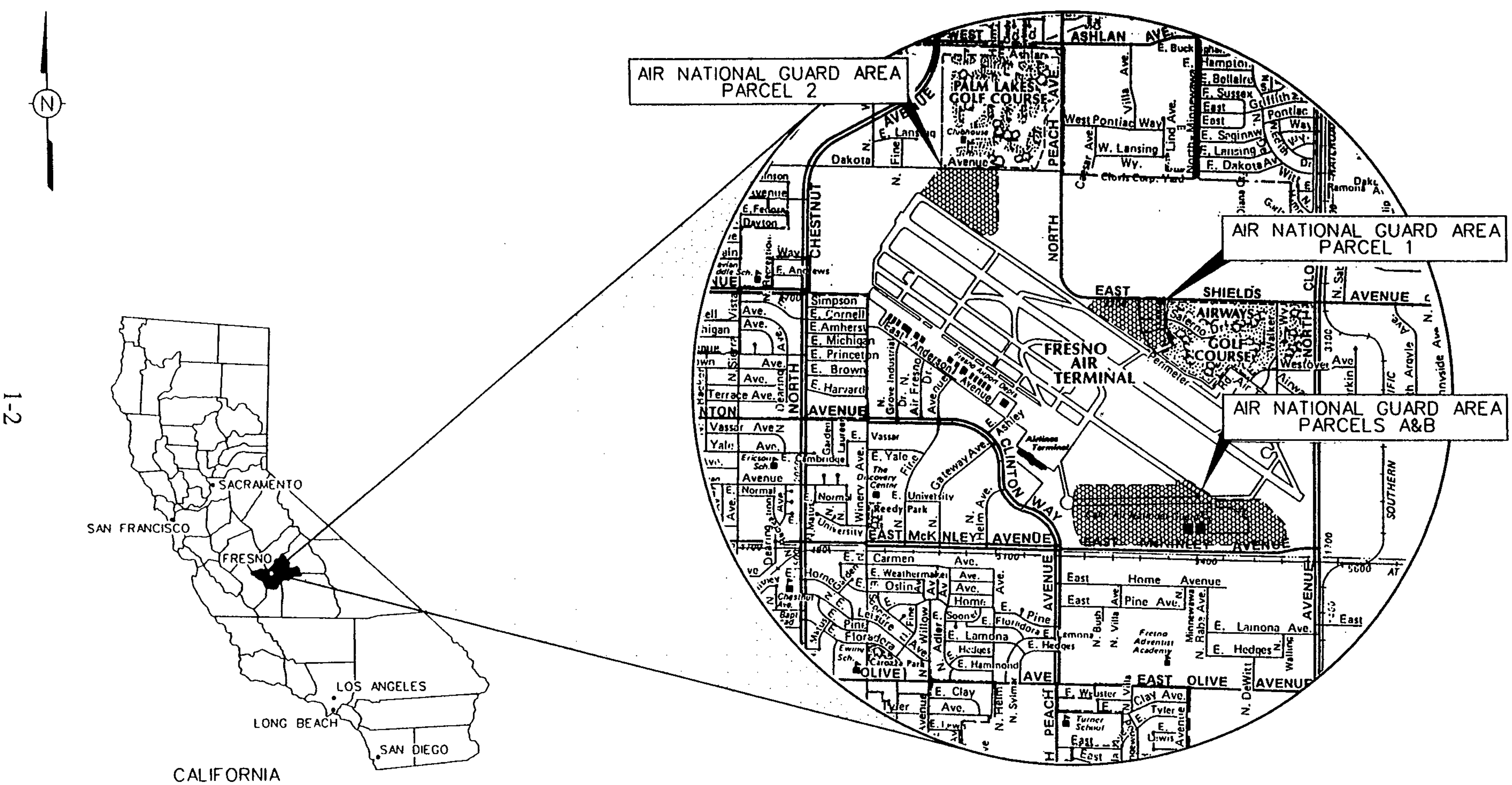

FIGURE 1-1
VICINITY MAP

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE 04-08-96	DATE LAST REV.	DRAFT CHCK BY. C TUMLIN	INITIATOR: S.LOGAN	DWG. NO.409724ES.058
DRAWN BY: K.BLAIR	DRAWN BY:	ENGR CHCK BY: S.LOGAN	PROJ. MGR: D.BURTON	PROJ. NO.:409724

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Martin Marietta Energy Systems, Inc. (now Lockheed Martin Energy Systems, Inc.), operating subcontractor for DOE facilities at Oak Ridge, Tennessee, is providing technical assistance through the Hazardous Waste Remedial Action Program (HAZWRAP). IT Corporation (IT) was contracted by Lockheed Martin Energy Systems, Inc. to conduct a SI and provide a SI report that served as the basis for subsequent IRP activities.

Four sites were originally listed as IRP sites:

- Site 1 - Old Fire Training Area (FTA)
- Site 2 - Base Petroleum, Oil, and Lubricants (POL) Area
- Site 3 - Storage Area at the U.S. Marine Corps (USMC) Subleased Area
- Site 4 - Suspect Burial Area.

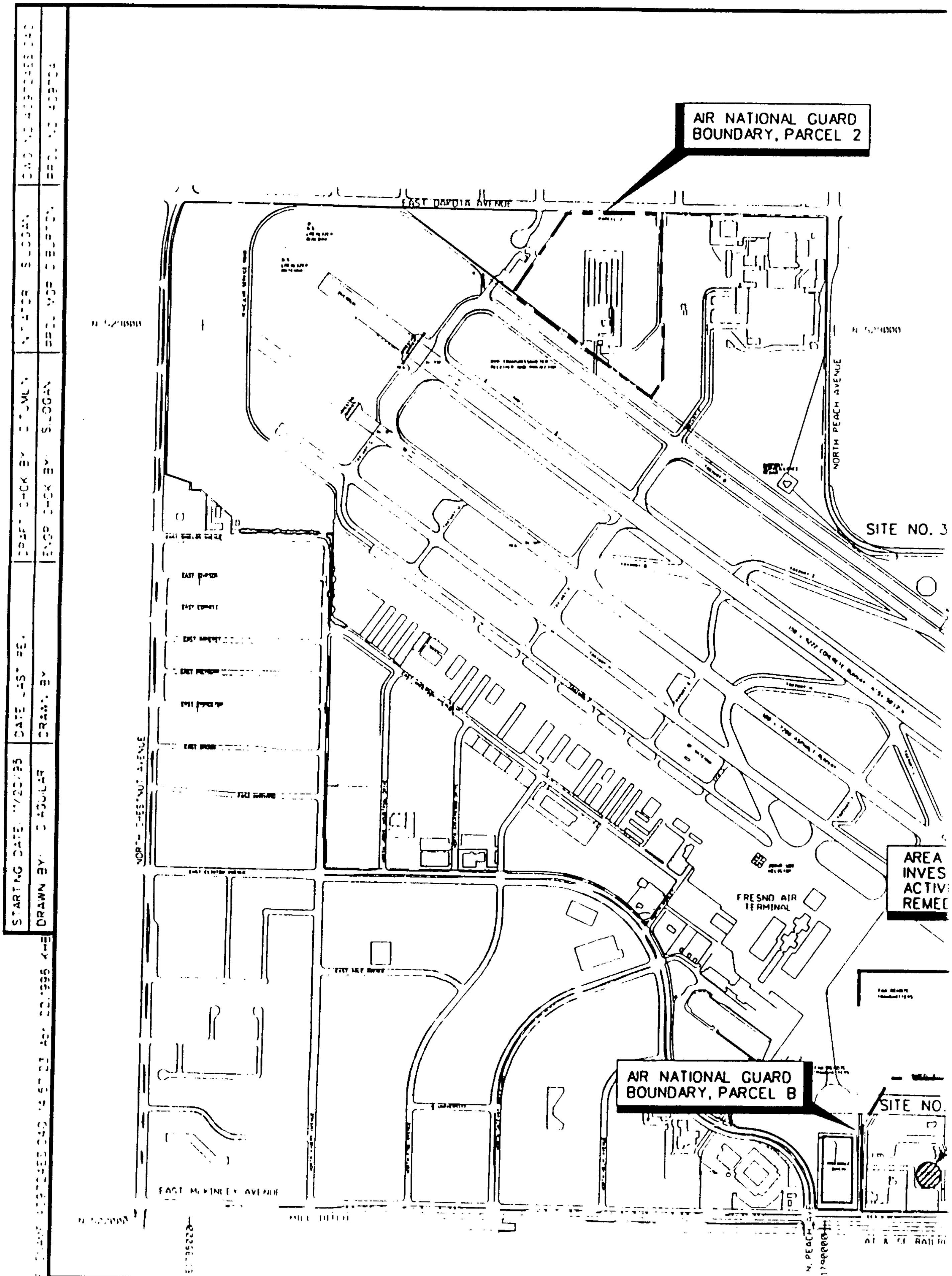
Sites 1, 2, and 3 were recommended for investigation as a result of a preliminary assessment (PA) that was completed in 1988 (Hazardous Materials Technical Center [HMTC], 1988). The fourth site was added to the SI program at the initiative of the ANGRC to investigate all areas of possible environmental concern. The SI was developed through the sampling and analysis plan (SAP), which was finalized in 1990 (IT, 1990). Plans were implemented in July 1990 and completed in February 1991. Site locations are shown in Figure 1-2. All SI activities, results, findings, and recommendations for the four SI sites are documented in the SI report (IT, 1992a) and the draft supplemental SI report (IT, 1996a), and will not be presented or discussed further, except as supplemental information relates to the RI.

As a result of the SI, a fifth site (Site 5-BCP) was added to the list of IRP sites. Sufficient information was gained from the SI to suspect Site 5-BCP as a potential source area for observed groundwater contamination in the uppermost saturated zone beneath the Base. After the issuance of the SI report in 1992 (IT, 1992a), the investigation program moved into a RI for characterizing subsurface conditions in and around Site 5-BCP.

1.3 Overview

This RI report presents and discusses all project-related information obtained at Site 5-BCP since the conclusion of the SI report (IT, 1992a). Investigation phases conducted between 1992 and 1995 include:

- Quarterly groundwater sampling and monthly groundwater monitoring program
- RI at Site 5-BCP and across the western portion of the Base


AIR NATIONAL GUARD
BOUNDARY, PARCEL 2
EAST DAKOTA AVENUE
NORTH PEACH AVENUE
SITE NO. 3
NORTH CHESTNUT AVENUE
AREA
INVES
ACTIV
REMED
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TERMINAL
AIR NATIONAL GUARD
BOUNDARY, PARCEL B
SITE NO.
EAST McKINLEY AVENUE
N. PEACH

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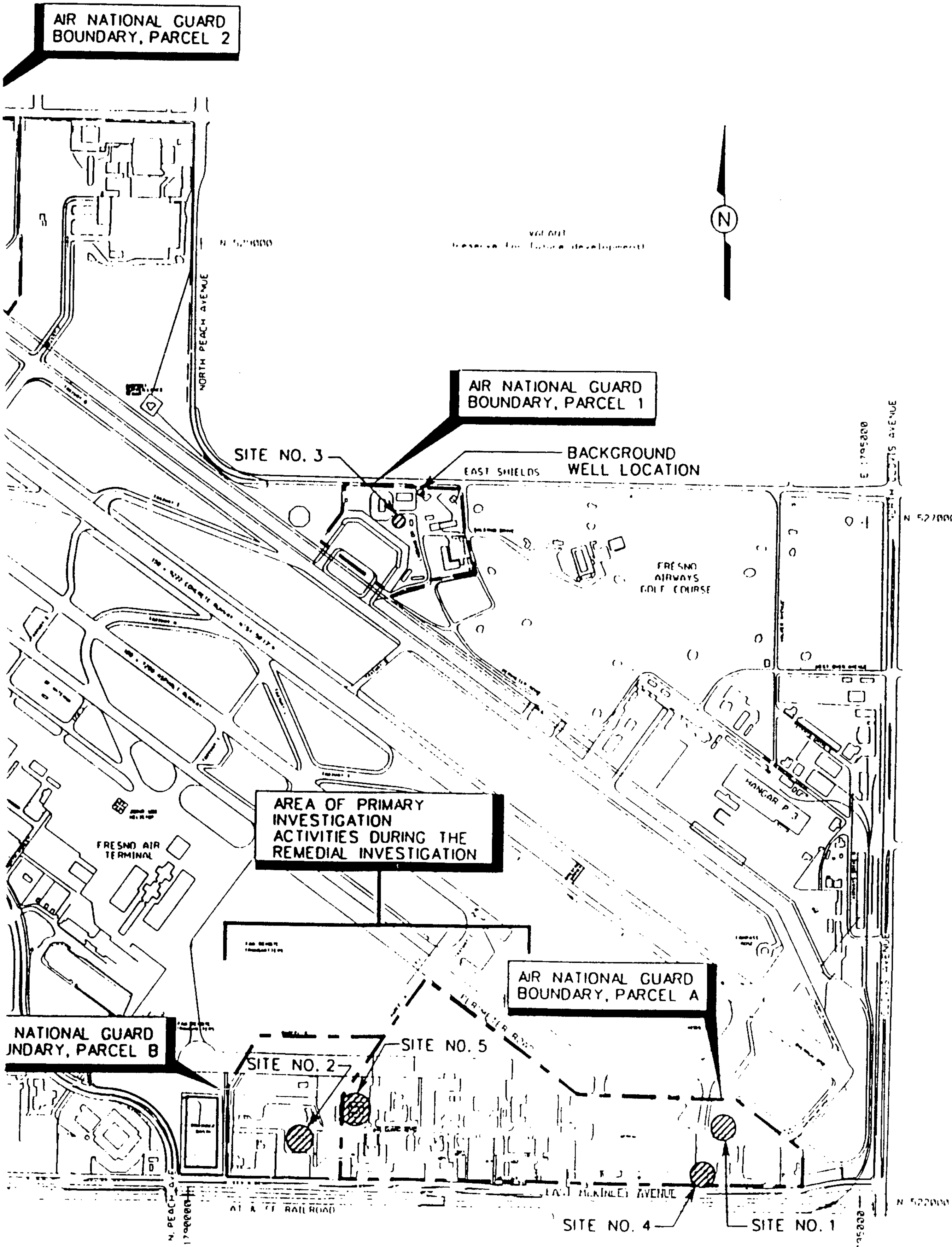

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FIGURE 1-2
BASE MAP
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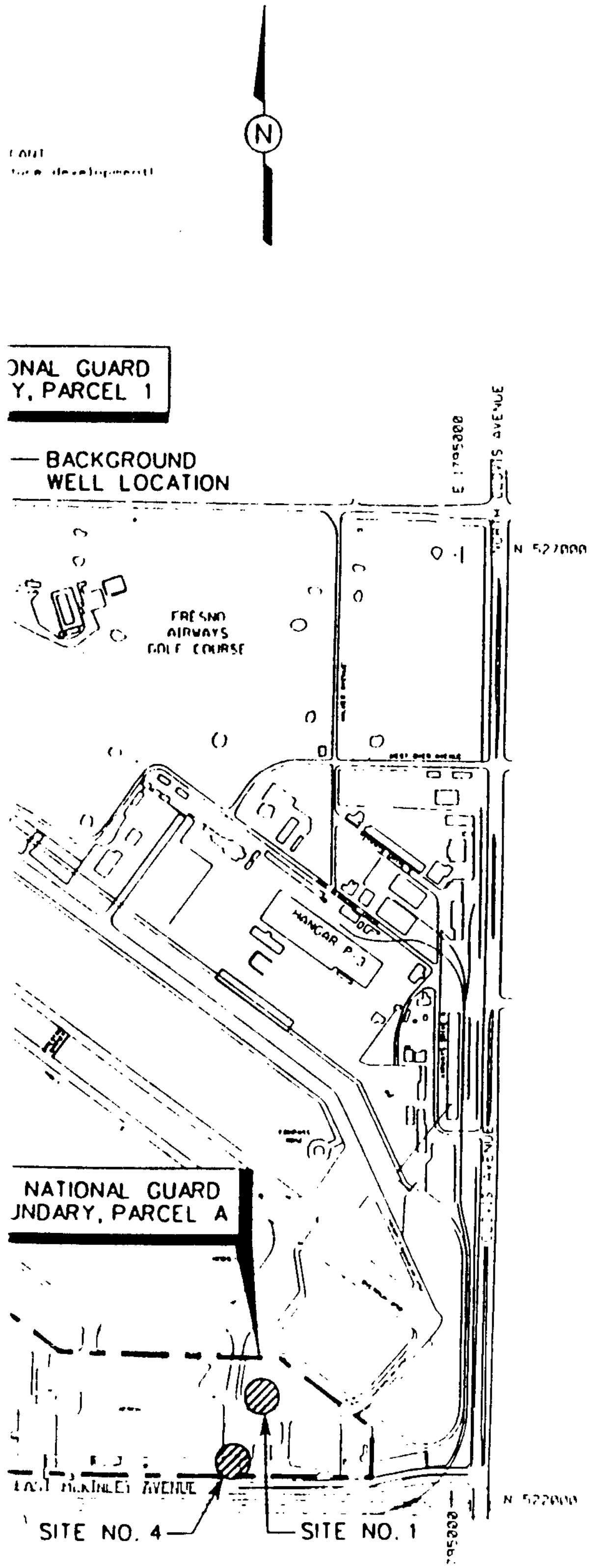


SCALE

0 1000 2000 FEET

FIGURE 1-2

BASE MAP LOCATION MAP OF
IDENTIFIED INVESTIGATION SITES

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL
TECHNOLOGY
CORPORATION

- Initial deep aquifer investigation
- Aquifer/pumping tests and deep monitoring well groundwater sampling.

Recommendations from the SI included a quarterly groundwater sampling and monthly groundwater elevation monitoring program, as well as the RI at Site 5-BCP. The quarterly sampling program was initiated in June 1992 and continued through May 1993. RI activities were conducted in late 1992 and comprised soil organic vapor sampling and monitoring well installation across the western portion of the Base. Soil and groundwater screening sampling, followed by confirmation analyses, were performed as a part of the RI.

Through the SI and quarterly groundwater monitoring programs, the lateral extent of groundwater contamination in the uppermost water-bearing zone was characterized. The initial deep aquifer investigation was designed and conducted to characterize the vertical extent of contamination associated with past Base use and/or disposal practices. This phase of activities was performed from October through December 1993. Aquifer tests were then performed in March 1995 as a final phase of the deep aquifer investigation to better define hydrogeologic parameters within the aquifer zones of concern. Table 1-1 shows the investigation programs conducted at the Base, and their sequence with respect to this RI report.

1.4 Report Organization

This RI report is formatted to resemble other RI reports supported by the ANGRC. This chapter reviews the purpose of the RI report, presents an overview of the RI in relation to previous investigations, and describes the general history of the project. The objective of this chapter is to provide the framework within which the RI was developed and conducted.

Chapter 2.0 describes the history of the Fresno ANG Base and the five identified sites. Additionally, this chapter presents findings from previous work performed at the Base and the conclusions and recommendations arising from this work. This provides the basis for the RI.

Chapter 3.0 defines the physical characteristics of the regional and local study area. Most of the relevant information to the environmental setting is presented over a Basewide perspective because settings for the individual sites are similar to each other.

Investigation programs and procedures employed throughout the RI are summarized in Chapter 4.0. Specific data objectives of each phase of the investigation are also presented in Chapter 4.0.

Table 1-1

Summary of Investigation Programs
California Air National Guard - Fresno, California

Item	Year	IRP Activity	Documentation	Year
1	1988	Preliminary Assessment	Preliminary Assessment	1988
2	1990-91	Site Investigation	Site Investigation Report	1992
3	1992-93	Quarterly Groundwater Sampling Program	Quarterly Groundwater Monitoring Report, April 1993	1993
4	1992	Site 5 - BCP Remedial Investigation	Interim Report of Findings, Focused RI	1993
5	1993	Initial Deep Aquifer Investigation (IDAI)	IDAI Technical Memorandum	1994
6	1995	Aquifer/Pumping Tests	Groundwater Sampling/Pumping Test Technical Memorandum	1996
7	1995	Baseline Risk Assessment	Remedial Investigation Report	Present
8	Present	Items 2 and 3	Supplemental Site Investigation Report	Present
9	Present	Items 3 through 7	Remedial Investigation Report	Present

Chapter 5.0 contains geologic and hydrogeologic settings and interpretations stemming from each subsurface investigation at and around Site 5-BCP. This information provides a backdrop for sample result explanations as they relate to extent and migration analysis.

Chapter 6.0 presents the results of environmental sampling events during the RI and discusses nature and extent of contamination associated with Site 5-BCP soil and areawide groundwater. Relevant data from previous studies are included in Chapter 6.0.

Chapter 7.0 provides an initial discussion of applicable or relevant and appropriate requirements (ARAR) in preparation for identifying a remedial action. Because remedial actions must comply with state and federal environmental laws, a framework for meeting ARARs is included in this report.

An evaluation of possible fate and transport scenarios for site-related contaminants is presented in Chapter 8.0. Potential routes of migration and physical characteristics of chemicals of concern (COC) are considered in this evaluation.

Chapter 9.0 presents the risk assessment that was recommended in the SI. Risks are evaluated for various human health exposure scenarios resulting from constituents in soil and groundwater at the different sites within the Base. This chapter evaluates risks posed from exposure to groundwater on a more regional scale.

Chapter 10.0 includes a summary of RI activities and presents conclusions based on the evaluations of soil and groundwater data. Information included throughout the report is compiled to substantiate the conclusions drawn in this chapter.

Based on the conclusions, Chapter 11.0 provides recommendations for further work at the Base.

A reference list of sources used in preparing this document is included as Chapter 12.0.

Appendices to this report contain detailed data supporting the RI, and include boring logs, well construction specifications, analytical data, and other relevant information.

2.0 Facility Background

2.1 Facility History

The Fresno Air Terminal (FAT), located within the San Joaquin Valley of central California, is base for the 144th Fighter Wing (FW), California ANG. The 144th FW originally flew out of Oakland Municipal Airport in 1948 and moved to Hayward, California in 1951. Operations first began in Fresno in 1955 with the advent of jet aircraft. Before 1955, FAT was referred to as Hammer Field and was used by the U.S. Army.

The California ANG leases approximately 140 acres of land from the City of Fresno on four different parcels inside the airport boundaries (Figure 1-2). Sites 1, 2, 4, and 5 are located in the main leased parcels (Parcels A and B), which are bounded on the south by McKinley Avenue. On Parcel 1, bordered by Shields Avenue and taxiway B, the 144th FW hosts the USMC (Reserve) 4th Light Antiaircraft Motorized Battalion (LAAM BN). Site 3 is in the area subleased by the USMC. Parcel 2, located immediately south of Dakota Avenue, does not contain any suspected contaminated sites. RI activities took place on Parcels A and B (Figure 1-2).

Missions of the 144th FW are to recruit, administer, and train ANG personnel and to maintain combat-ready equipment for short-notice mobilization for air defense of central California and the west coast of the United States.

2.2 Preliminary Assessment

In April 1988, a PA was completed by HMTC focusing on past and present generation use, handling, and disposal practices of hazardous waste and materials. Based on HMTC's findings, three suspect sites were identified as being potentially contaminated with hazardous waste/hazardous materials. These sites were assigned a Hazard Ranking Score according to the U.S. Air Force Hazardous Assessment Rating Methodology. Because of the potential for contamination and contaminant migration to groundwater, further IRP investigation was recommended.

The PA identified Sites 1, 2, and 3. Site 4, suspected of being a former burial area where waste materials, either intentionally or inadvertently, may have been disposed, was added by the ANGRC. The suspect burial area was added as a commitment by the ANGRC to assess the extent of contamination and to confirm environmental quality at the Base.

2.3 Site Descriptions

FAT is within the corporate boundaries of Fresno, specifically in Range 20, Township 13, Sections 19, 29 and 30. The city of Clovis lies approximately 4 miles north of FAT. Areas north, west, and south of FAT are predominantly residential and industrial, while the area east of the airport is mainly agricultural (City of Fresno, 1990).

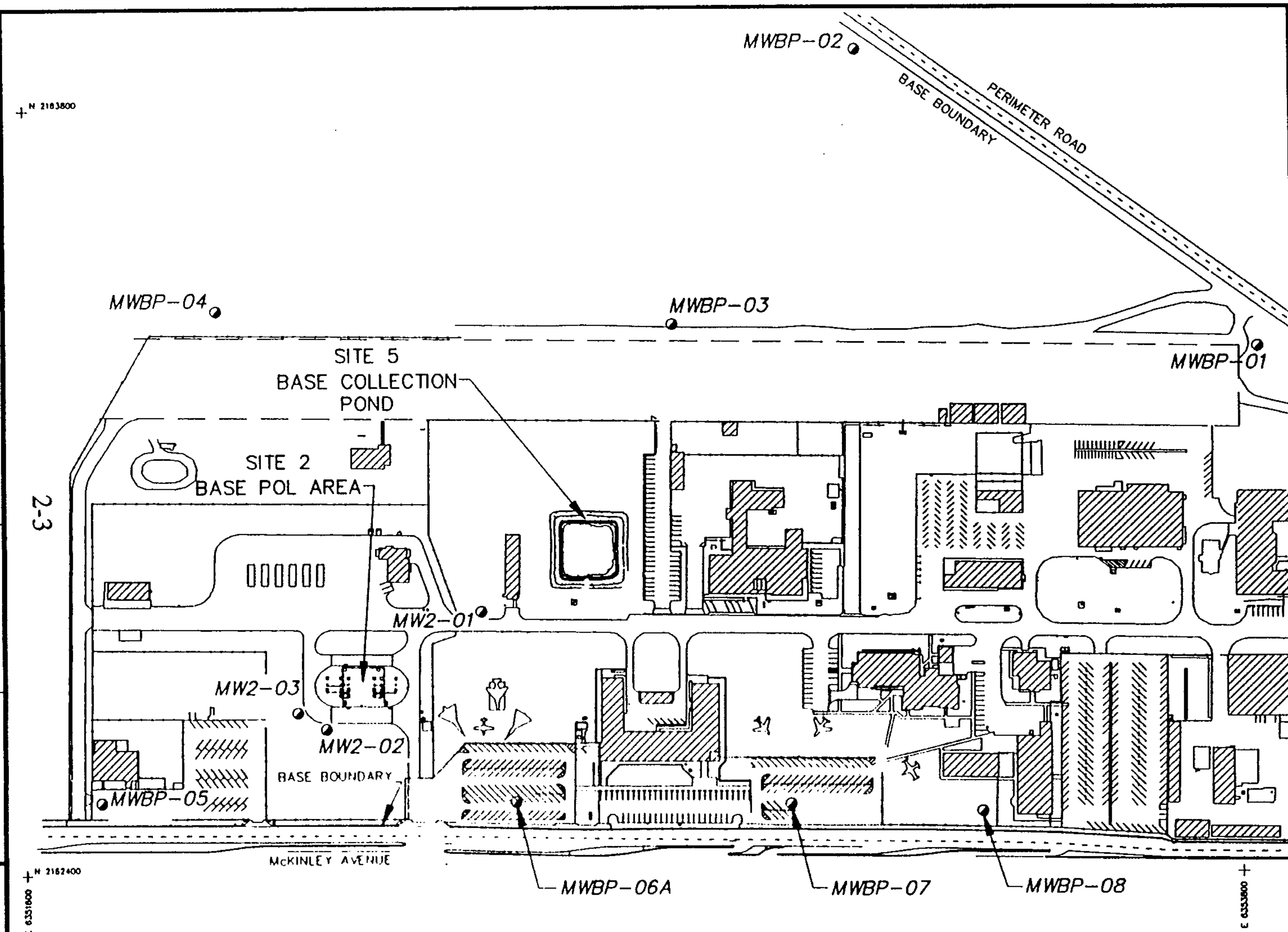
Site descriptions of the four SI sites are available in the SI report and draft Supplemental SI report (IT, 1992a; 1996a).

Site 5 - Base Collection Pond. Site 5 was added as a result of activities and sampling data generated during the SI. The location of the BCP within the western portion of the Base is shown in Figure 2-1.

The BCP was a collection sump that periodically received washdown waters and storm runoff from drains across the western portion of the Base and from portions of McKinley Avenue. Water was allowed to percolate through soil at the pond to the regional water table. Infiltration was originally aided by five vertical gravel wells that were installed in the bottom of the BCP in the 1970s. Over time, however, the wells became clogged with sediment and their ability to transmit water was diminished.

The BCP covered an area of approximately 19,000 square feet and had steeply sloping sides down to the bottom, which was approximately 12 feet below ground surface (bgs). Three inflow pipes released washdown water and runoff to the BCP.

In early 1995, a request to construct at Site 5 was granted by the State of California, Department of Toxic Substances Control (DTSC). Approval was based on findings from investigations (presented herein in their entirety) that indicate that soils at Site 5 do not pose a threat to human health or the environment and are not a continuing source of contamination to groundwater. Presently, the BCP has been filled to grade with clean soil and, therefore, no longer exists as it did during previous investigations. The former BCP will later be converted into an aboveground fuel storage tank farm that will serve as a new location for the Base POL Area. Subsequently, the area will be capped with asphalt or concrete by the year 2007.



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MWBP-03 MONITORING WELL INSTALLED DURING SITE INVESTIGATION

SCALE: 0 200 400 FEET

FIGURE 2-1
LOCATION DETAIL OF SITES 2 AND 5

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

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DRAWN BY: D BILLINGSLEY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

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2.4 Site Investigation at Site 5-BCP

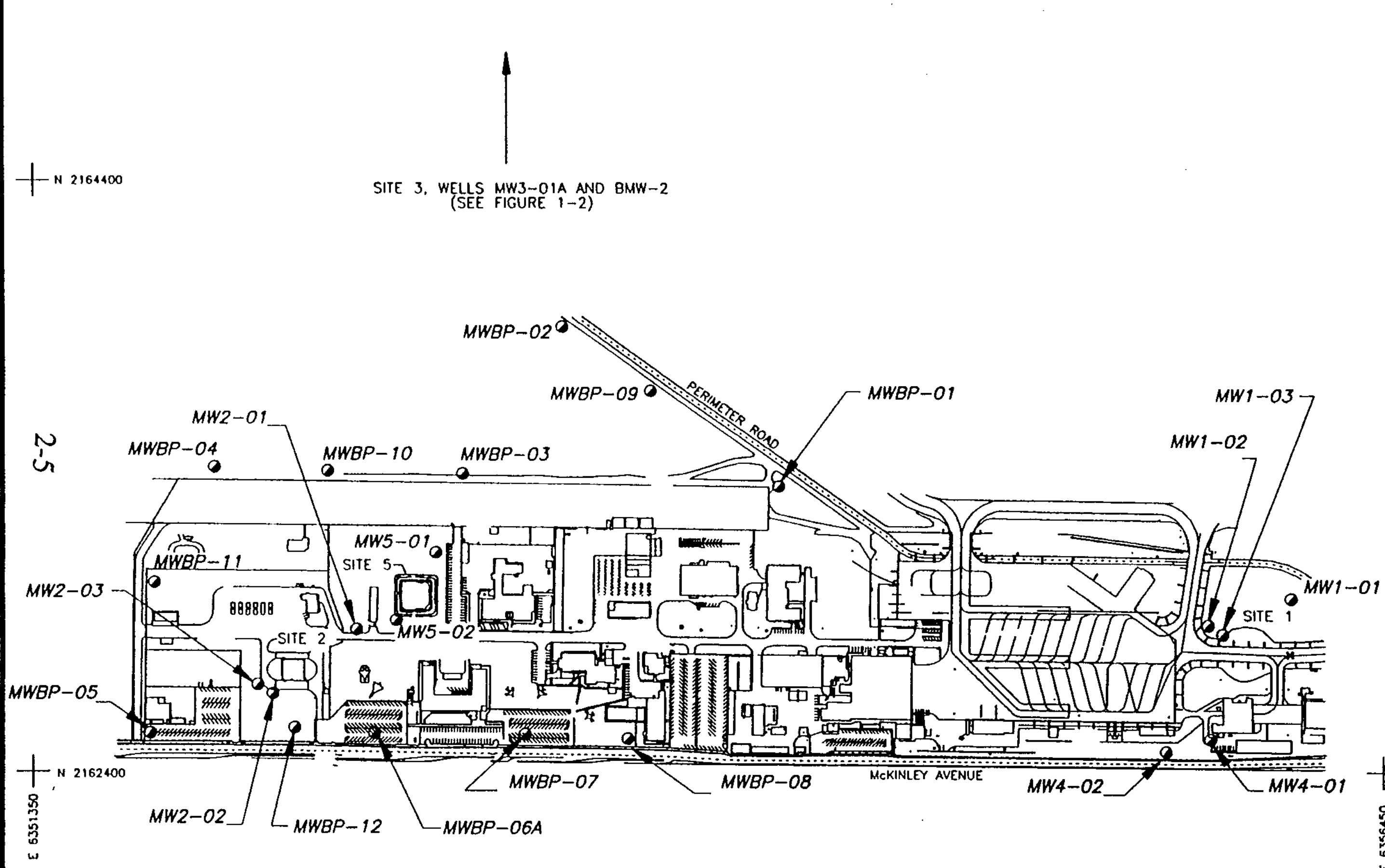
As a result of the PA, Fresno ANG was included in the ANGRC's IRP for further investigative activities. The IRP adopted an expanded approach to an SI such that data obtained would be sufficient to allow one of the following recommendations:

- Take no further action.
- Begin a focused feasibility study (FS)/remedial measure.
- Expedite an immediate remedial response.
- Expand the study to an RI/FS.

SI field activities began with the preparation of plans to acquire field data that satisfy the objectives of the SI. Project plans were implemented from July 1990 through February 1991. Specific objectives of the SI included: identifying specific chemical contaminants in soil and groundwater; evaluating site hydrogeology, chemical migration pathways, and groundwater flow patterns; establishing the geologic and hydrogeologic database for the study sites; and evaluating potential receptors for migrating contamination.

During the SI, eight monitoring wells were installed around the perimeter of Base property within the western portion of the Base (Figure 2-2). Groundwater samples from these Base perimeter wells showed that trichloroethene (TCE) was present in groundwater upgradient of the Base and perchloroethene (PCE) was present within and downgradient of the Base. A regional investigation of FAT property (also referred to as Old Hammer Field) by others has implicated an area known around Hanger P-3 (Figure 2-3) as the likely source area for TCE groundwater contamination (ERM-West, Inc. [ERM], 1992 and 1994). Figure 2-3 shows the estimated extent of TCE in shallow groundwater across FAT, based on this and other investigations. Hangar P-3 is located approximately 2,500 feet northeast of Base property.

The BCP was identified as a possible source area for PCE groundwater contamination. As a result, the BCP was preliminarily investigated during a supplemental phase of the SI. During the SI, four shallow borings were advanced to depths of 3 feet. Eight shallow soil samples analyses did not detect volatile organic compounds (VOC); estimated concentrations of some semivolatile organic compounds (SVOC) were detected. Results from shallow soil samples, collected between depths of 1 and 3 feet, did not indicate that contaminants were currently being introduced into the BCP. However, additional investigation was recommended to identify the potential source of PCE contamination in groundwater and Site 5-BCP was added to the list of IRP sites.



MW2-01 MONITORING WELL

SCALE:

0 400 800 FEET

FIGURE 2-2

SITE AND MONITORING WELL LOCATIONS, MAIN BASE PROPERTY

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

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STARTING DATE: 10/16/95	DATE LAST REV.:	DRAFT. CHCK. BY: C. TUMUN	INITIATOR: S. LOGAN	DWG. NO.: 409724-B-105
DRAWN BY: D. BILLINGSLEY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

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STARTING DATE: 4/16/96	DATE LAST REV.:	DRAFT. CHCK. BY: K. WOOD	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.065
DRAWN BY: K. WOOD	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

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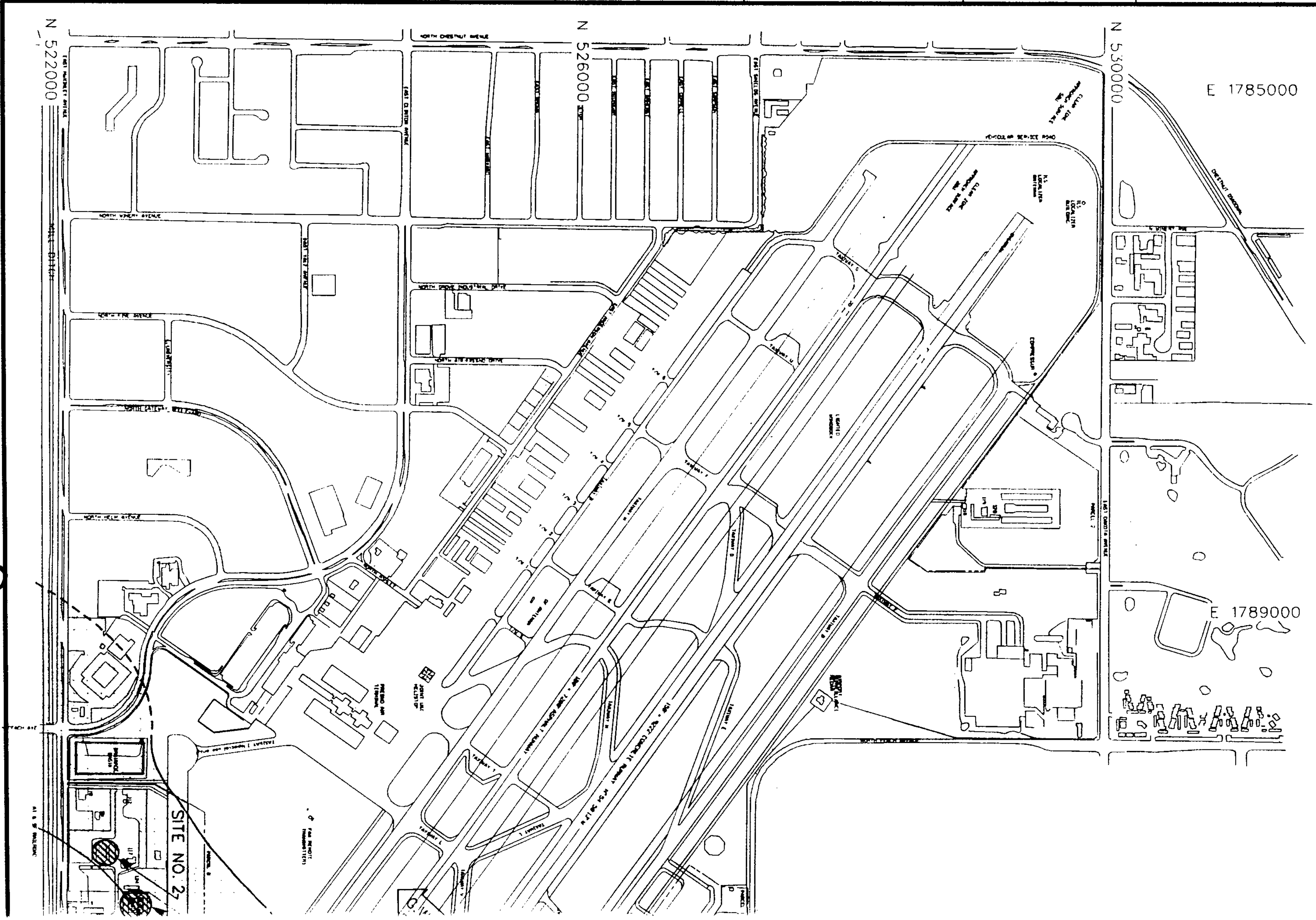

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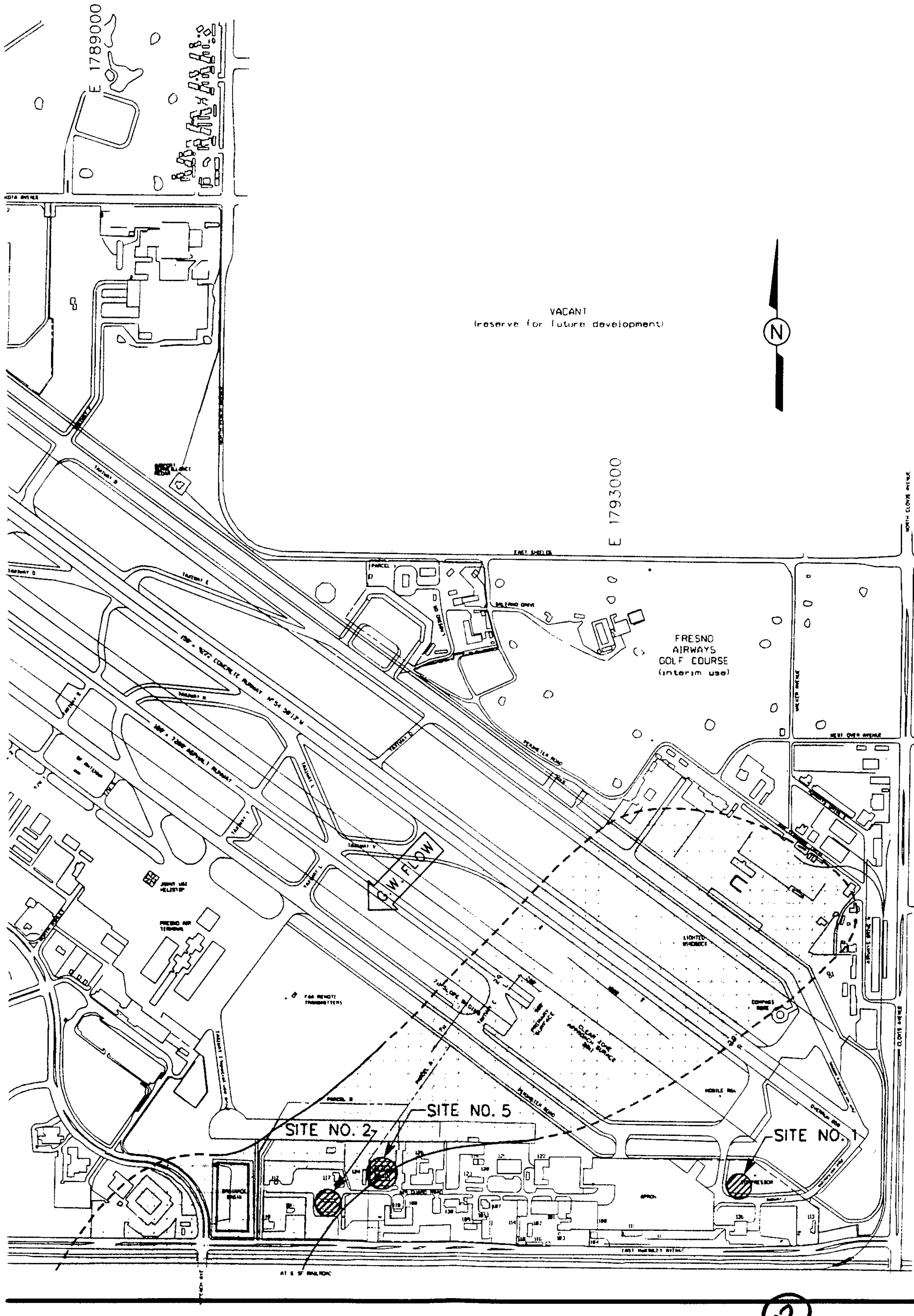

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G.W. F

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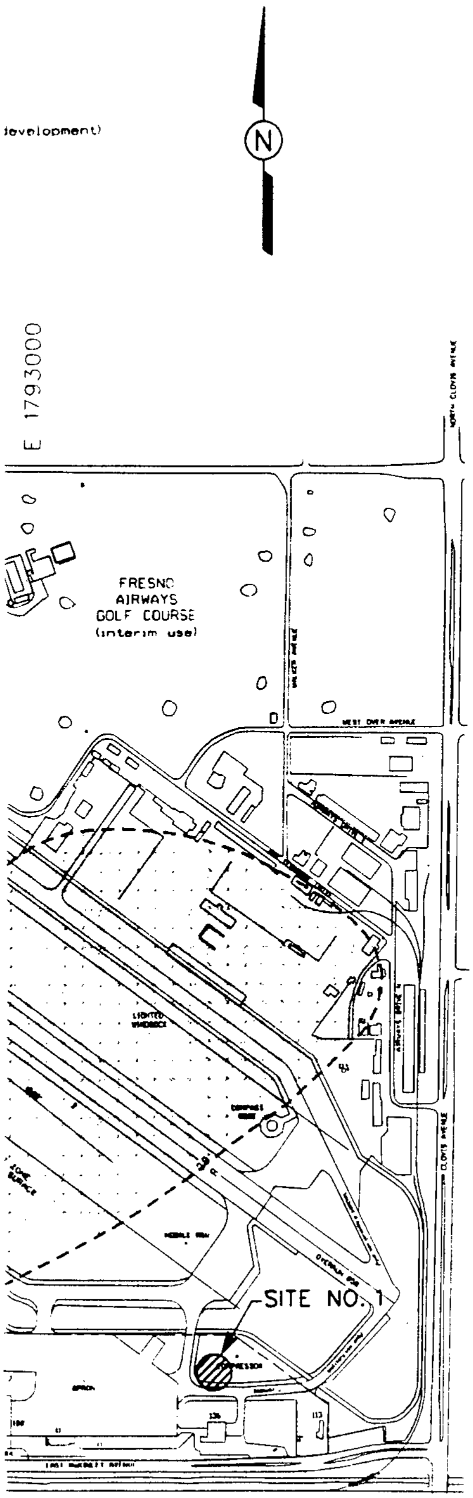
(2)



LEGEND:

PROPERTY BOUNDARY

TCE PLUME AREA
(DASHED WHERE ESTIMATED)

G.W. FLOW — GROUNDWATER FLOW DIRECTION

SOURCE: ADAPTED FROM ERM, 1994.

SCALE

0 1000 2000 FEET

FIGURE 2-3
ESTIMATED TCE PLUME DISTRIBUTION
IN SHALLOW GROUNDWATER,
OLD HAMMER FIELD

CALIFORNIA AIR NATIONAL GUARD
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3

Because downgradient PCE contamination in groundwater was found, the following actions were recommended and later implemented in the RI:

- Conduct a soil organic vapor (SOV) survey across the western portion of the Base to delineate areas of high soil gas concentrations of VOCs.
- Install additional perimeter and BCP monitoring wells to characterize upgradient, site-related, and downgradient groundwater conditions.
- Drill and sample additional soil borings to identify a potential source of PCE contamination.

These activities were conducted during the RI and are discussed in Section 4.2 Results are presented in Sections 5.2 and 6.2.

3.0 Environmental Setting

3.1 Meteorology

The climate in the Fresno area is characterized by hot, dry summers and cool, moist winters. Mean monthly temperatures range from approximately 46 degrees Fahrenheit (^{o}F) in December to 85^{o}F in July. Average annual precipitation is less than 10 inches; more than 90 percent of the yearly rainfall occurs between October and April, as summarized in Table 3-1. Rainfall varies widely from year to year and shows long-term wet and dry periods. The mean evaporation rate is 66 inches per year.

3.2 Physiography and Topography

The Central Valley of California comprises approximately 20,000 square miles, with an average width of 50 miles and length of 400 miles, extending from Red Bluff in the north to Bakersfield in the south. Fresno is situated in the southern third of the Valley on its eastern side. The Central Valley is bordered on the west by the Coast Ranges, which rise to an altitude of 4,000 feet, and on the east by the Sierra Nevada, which rise to 14,000 feet in places. The elevation of the Central Valley is less than 1,000 feet, on average.

Two valleys make up the Central Valley; the northern third of the Valley is known as the Sacramento, and the southern two-thirds is known as the San Joaquin. The rivers of the San Joaquin originate in the Sierra Nevada and join with the Sacramento River in the north to flow into the Suisun Bay. Two large perennial, meandering streams flow through the Fresno area: the San Joaquin River north of Fresno, and the Kings River south of Fresno. The Fresno Slough Bypass connects these two rivers. Further south is an area dominated by internal drainage to the low-lying Tulare Lake area (altitude 180 feet), which in wet years may fill with water that spills northward into the San Joaquin River.

The most extensive geomorphic units in the Valley include dissected uplands, low alluvial plains and fans, river floodplains and channels, and overflow lands and lake bottoms. Fresno lies in an area dominated by alluvial plains and fans.

3.3 Human and Ecological Survey

The California ANG leases 126.3 acres of land from the City of Fresno on three different parcels inside the boundaries of the FAT (Fresno ANG, 1990). The majority of the land at the Base is either paved or has been developed (contains buildings or other structures used for

Table 3-1

Summary of Rainfall Data, Fresno, California
California Air National Guard - Fresno, California

Station Information - Lat. 36°46'N, Lon. 119°43'W; Elevation 328 feet; Time Zone, Pacific

Precipitation (inches)	a	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Normal	36	2.05	1.85	1.61	1.15	0.31	0.08	0.01	0.02	0.16	0.43	1.24	1.61	10.52
Maximum monthly	36	8.56	5.97	5.79	4.41	1.56	0.60	0.08	0.25	1.19	1.58	3.50	6.73	
Year		1969	1962	1958	1967	1957	1972	1979	1964	1976	1982	1972	1955	
Maximum in 24 hours	36	2.59	1.99	1.63	1.39	0.96	0.60	0.08	0.25	0.97	1.55	1.35	1.76	
Year		1969	1969	1958	1983	1957	1972	1979	1964	1978	1976	1953	1955	

[a]Length of record, in years (1956-1985).

Source: Ruffner and Bair, 1987, *Weather of U. S. Cities.*

KN/3069/WP3069.3-1/01-29=97(11:59am)/F1/E(01-28-97)

the maintenance or support of military operations). Approximately 30 percent of the land is open.

The land adjacent to the FAT is classified as either open space/recreational or as light industrial (City of Fresno, 1990). The west side of the terminal includes heavy commercial development as well as light industries. The Base comprises the southeastern area of the FAT. The areas north, west, and south of FAT are predominantly residential and industrial, while the area east of FAT is primarily agricultural. Because of the existence of a large airport, it is unlikely that the Base will be used for any purpose not associated with either ANG or commercial operations associated with FAT.

The general population surrounding the Base is divided into on-site and off-site populations. The on-site population consists of personnel working full-time at the Base, individuals who train at the Base, and contractors who may be employed to perform on-Base activities. The Base does not have on-Base housing; therefore, there is no residential population at the Base. The off-site population consists of those people who work in the commercial or light industrial areas, who live in the area, or who use the recreational facilities in the area.

The environment at the Base represents a controlled ecosystem. Vegetation consists primarily of shrubs, trees, or grasses planted for aesthetic or landscaping purposes. Wildlife at the Base consists of animals adapted to surviving in this type of environment. These include gophers, ground squirrels, mice, rats, and birds. There have been no endangered or threatened biological species identified within a 1-mile radius of the Base (Fresno ANG, 1990).

3.4 Soil Conditions

Soils at the Base can be classified by the depositional history of the parent alluvium, which is composed predominantly of weathering products from granitic rocks. Recent alluvium consists of relatively unweathered granitic sediment deposited on floodplains and fans. These deposits are coarse-textured and helped to develop the Hanford series soils. Young alluvium, deposited before recent alluvium, consists of several feet of relatively coarse-textured material overlying thick silty layers interbedded with sand. In well-drained fans, silty substrata of the young alluvium have formed the Hanford series soils. Where deposits of young alluvium have been reworked by aeolian action, Atwater series soils have formed (U. S.Department of Agriculture [USDA]-Soil Conservation Service, 1971).

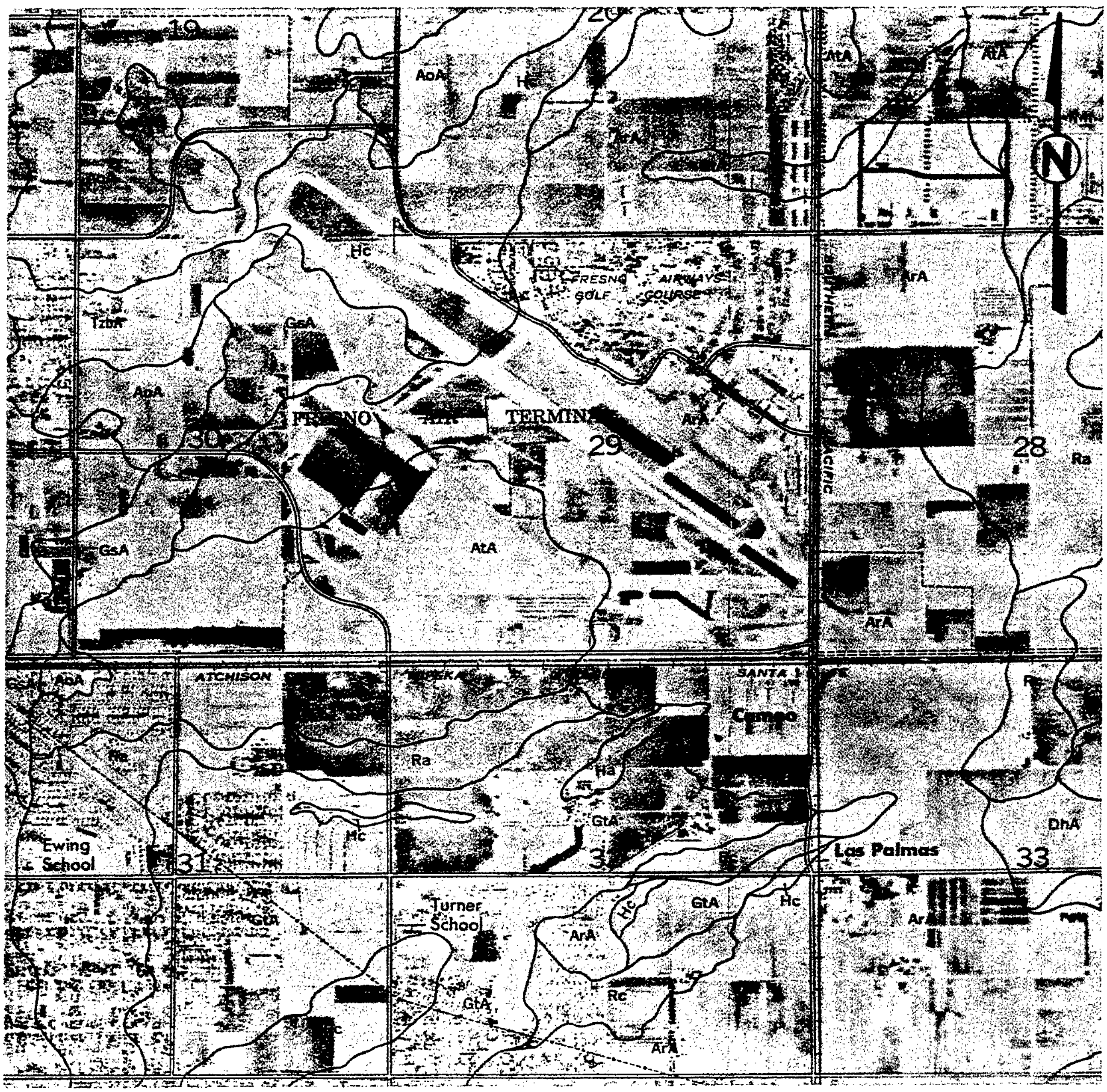
The Atwater and Hanford series are the primary soil series found on and around the Base. Sites 2 and 5 are identified as Atwater series soils (Figure 3-1). The surface layer consists of a light brownish gray sandy loam underlain by a brown sandy loam subsoil that presents only a slight resistance to water penetration. The depth to hardpan ranges from 4 to 7 feet. Moisture-holding capacity of the Atwater sandy loam is low because plant roots are restricted by the hardpan. In soil zones not dominated by hardpan, vertical permeabilities are moderately rapid and range from 2 x 10^{-3} centimeters per second (cm/s) to 3.5 x 10^{-3} cm/s in the subsoil to a limit of 7 x 10^{-3} cm/s in the surface and the immediately underlying substratum.

3.5 Regional Geology and Hydrogeology

Geology. Fresno lies in the Central Valley (also known as the Great Valley) province of California. The Central Valley is a large, elongated, northwest trending, asymmetrical structural trough that is bounded on the east by the Sierra Nevada range and on the west by the Coast Ranges. It has been filled with a thick sequence of sediment ranging in age from Jurassic (some 200 million years before present) to recent. In some areas, the sediments can be as thick as 5 or 6 miles. Figure 3-2 shows the regional geologic setting and Figure 3-3 provides the geologic setting on a more local scale.

The eastern portion of the Central Valley is underlain by a shelf of Sierra Nevada granitic rock that are directly overlain by consolidated sedimentary rocks of marine and continental origin. These sedimentary rocks are made up of Cretaceous and Tertiary sandstones, sands, siltstones and shales. Overlying these are unconsolidated deposits of Quaternary age. The major portion of these are derived from the granitic rocks of the Sierra Nevada (Figure 3-2), but some come from the Coast Ranges. These unconsolidated deposits are made up of (from deeper and older, to shallower and younger) older alluvium, lacustrine and marsh deposits, younger alluvium, flood basin deposits, and sand dunes. Quaternary age deposits beneath the Base include alluvium, flood-basin, lacustrine, and marsh deposits (Figure 3-3) (Page and LeBlanc, 1969). Deposits generally include interbedded clays, silts, sands, and gravels of varying thicknesses. The lithology reflects deposition in a number of environments associated with glaciation of the nearby Sierra Nevada.

Morphology of the Fresno alluvial fans differs from that normally found in a semiarid climate such as the San Joaquin Valley. Figure 3-4 shows the mapped alluvial fans in the Fresno area. The fans are broad, with low relief and very gentle slope, giving the impression of a flat surface rather than an alluvial fan. This morphology is attributed a very humid, high



LEGEND:

ArA - ATWATER SANDY LOAM, 0 TO 3 PERCENT SLOPES

AtA - ATWATER SANDY LOAM, MODERATELY DEEP, 0 TO 3 PERCENT SLOPES

Hc - HANFORD SANDY LOAM

SCALE: 1"=2000'

SOURCE: U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, EASTERN FRESNO AREA, CALIFORNIA, SHEET No. 41

FIGURE 3-1
PREDOMINANT SOIL TYPES

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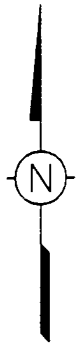
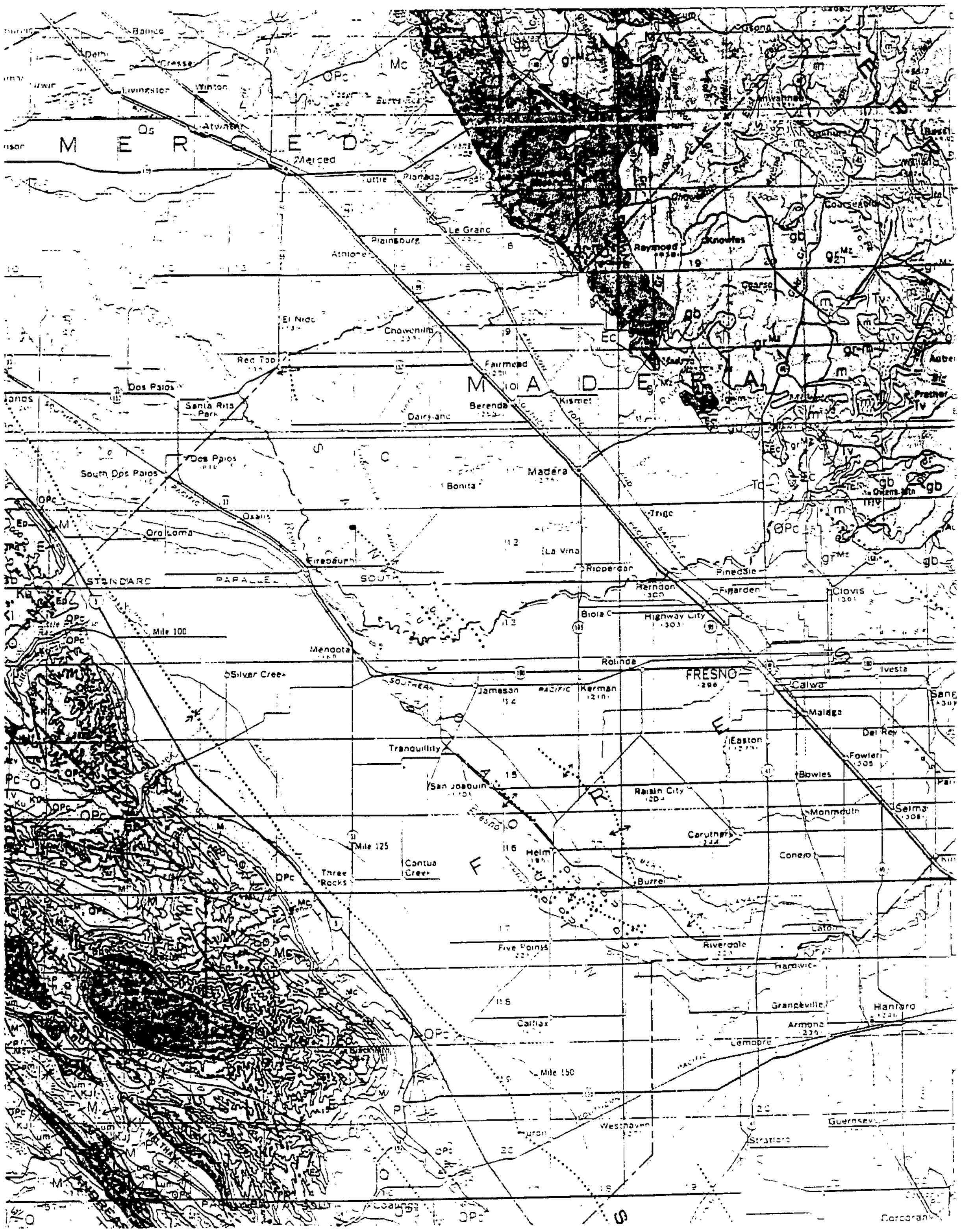
DRAWING NO.: 409679-A-C20
PROJECT NO.: 409679
INITIATOR: D. BURTON
PROJ. MGR. D. BURTON
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 3-31-89
DRAWN BY: S. MOORE

BRUNING 72425

DWG. NO.409724ES.053		INITIATOR: S.LOGAN		DRAFT. CHCK. BY: C TUMLIN		DATE LAST REV.:	STARTING DATE: 04-05-96
PROJ. NO.:409724		PROJ. MGR.: D.BURTON		ENGR. CHCK. BY: S.LOGAN		DRAWN BY:	DRAWN BY: K.BLAIR





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SOURCE:
JENNINGS, C.W., 1977, GEOLOGIC MAP OF CALIFORNIA, CALIFORNIA GEOLOGIC DATA MAP SERIES, MAP NO. 2

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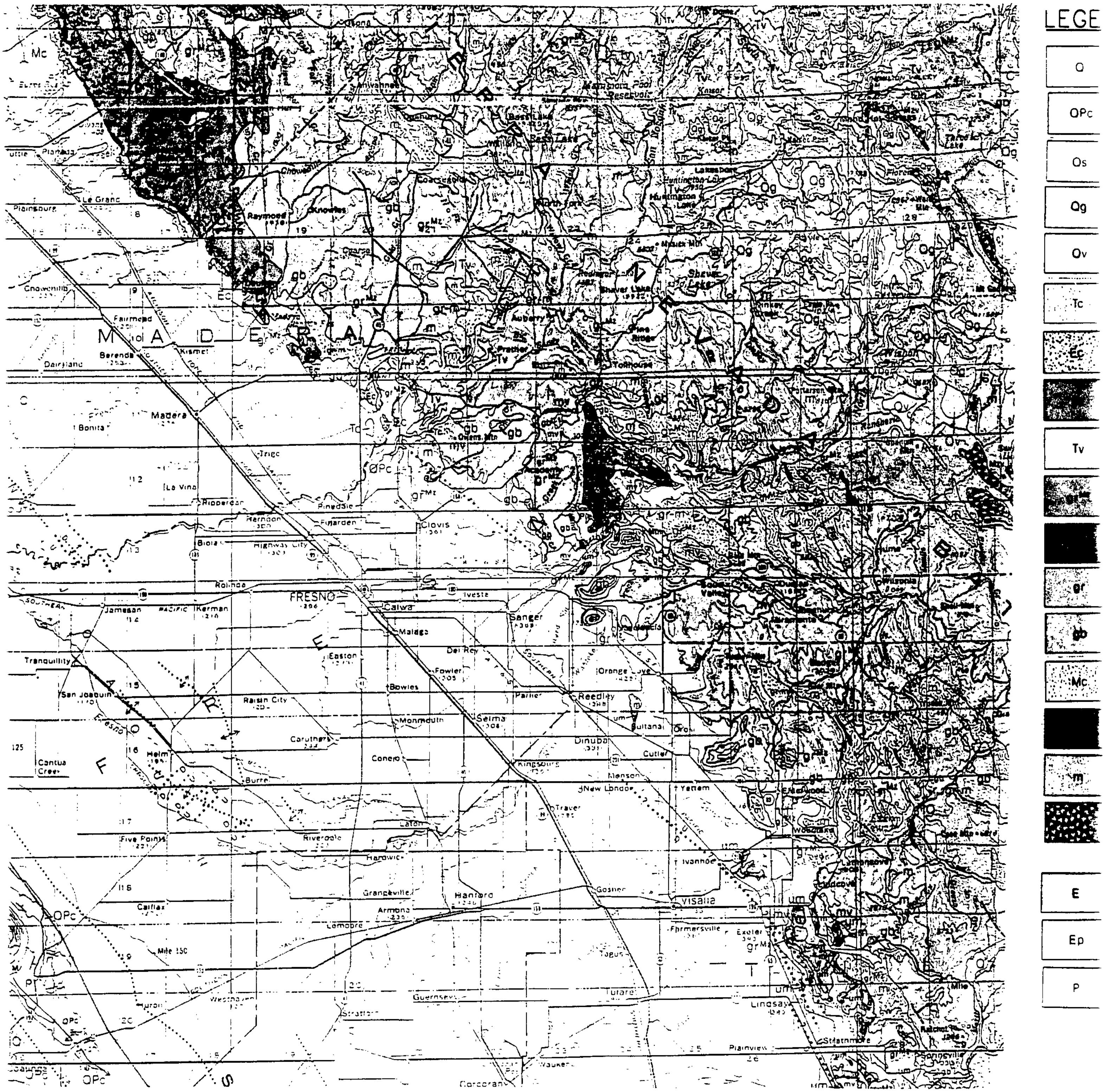
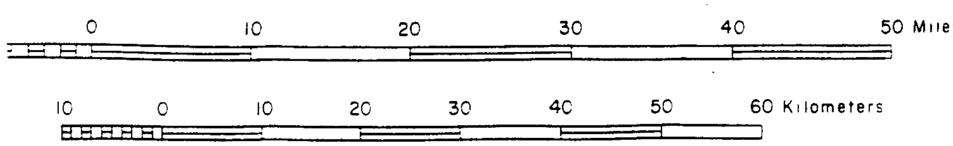


SCALE 1:750,000

(1 INCH EQUALS APPROXIMATELY 12 MILES)



750,000

XIMATELY 12 MILES)

30 40 50 Miles

30 40 50 60 Kilometers

LEGEND:

Q	ALLUVIUM, LAKE, PLAYA, AND TERRACE DEPOSITS; UNCONSOLIDATED AND SEMI-CONSOLIDATED. MOSTLY NONMARINE, BUT INCLUDES MARINE DEPOSITS NEAR THE COAST.
QPc	PLIOCENE AND/OR PLEISTOCENE SANDSTONE, SHALE, AND GRAVEL DEPOSITS; MOSTLY LOOSELY CONSOLIDATED.
Qs	EXTENSIVE MARINE AND NONMARINE SAND DEPOSITS, GENERALLY NEAR THE COAST OR DESERT PLAYAS.
Qg	GLACIAL TILL AND MORAINES. FOUND AT HIGH ELEVATIONS MOSTLY IN THE SIERRA NEVADA AND KLAMATH MOUNTAINS.
Qv	QUATERNARY VOLCANIC FLOW ROCKS; MINOR PYROCLASTIC DEPOSITS.
Tc	UNDIVIDED TERTIARY SANDSTONE, SHALE, CONGLOMERATE, BRECCIA, AND ANCIENT LAKE DEPOSITS.
Ec	SANDSTONE, SHALE, CONGLOMERATE; MODERATELY TO WELL CONSOLIDATED.
	UNDIVIDED PALEOZOIC METASEDIMENTARY ROCKS. INCLUDES SLATE, SANDSTONE, SHALE, CHERT, CONGOLMERATE, LIMESTONE, DOLOMITE, MARBLE, PHYLLITE, SCHIST, HORNFELS, AND QUARTZITE.
Tv	TERTIARY VOLCANIC FLOW ROCKS; MINOR PYROCLASTIC DEPOSITS.
	MESOZOIC GRANITE, QUARTZ MONZONITE, GRANODIORITE, AND QUARTZ DIORITE.
	FRANCISCAN COMPLEX: CRETACEOUS AND JURASSIC SANDSTONE WITH SMALLER AMOUNTS OF SHALE, CHERT, LIMESTONE, AND CONGLOMERATE. INCLUDES FRANCISCAN MELANGE, EXCEPT WHERE SEPARATED.
gr	UNDATED GRANITIC ROCKS.
gb	GABBRO AND DARK DIORITIC ROCKS; CHIEFLY MESOZOIC.
Mc	SANDSTONE, SHALE, CONGLOMERATE, AND FANGLOMERATE; MODERATELY TO WELL CONSOLIDATED.
	ULTRAMAFIC ROCKS, MOSTLY SERPENTINE. MINOR PERIDOTITE, GABBRO, AND DIABASE. CHIEFLY MESOZOIC.
m	UNDIVIDED PRE-CENOZOIC METASEDIMENTARY AND METAVOLCANIC ROCKS OF GREAT VARIETY. MOSTLY SLATE, QUARTZITE, HORNFELS, CHERT, PHYLLITE, MYLONITE, SCHIST, GNEISS, AND MINOR MARBLE.
	UNDIVIDED MESOZOIC VOLCANIC AND METAVOLCANIC ROCKS. ANDESITE AND RHYOLITE FLOW ROCKS, GREENSTONE, VOLCANIC BRECCIA AND OTHER PYROCLASTIC ROCKS IN PART STRONGLY METAMORPHOSED. INCLUDES VOLCANIC ROCKS OF FRANCISCAN COMPLEX: BASALTIC PILLOW LAVA, DIABASE, GREENSTONE, AND MINOR PYROCLASTIC ROCKS.
E	SHALE, SANDSTONE, CONGLOMERATE, MINOR LIMESTONE; MOSTLY WELL CONSOLIDATED.
Ep	SANDSTONE, SHALE, AND CONGLOMERATE; MOSTLY WELL CONSOLIDATED.
P	SANDSTONE, SILTSTONE, SHALE, AND CONGLOMERATE; MOSTLY MODERATELY CONSOLIDATED.

FIGURE 3-2
REGIONAL GEOLOGIC MAP OF THE FRESNO AREA

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FRESNO, CALIFORNIA

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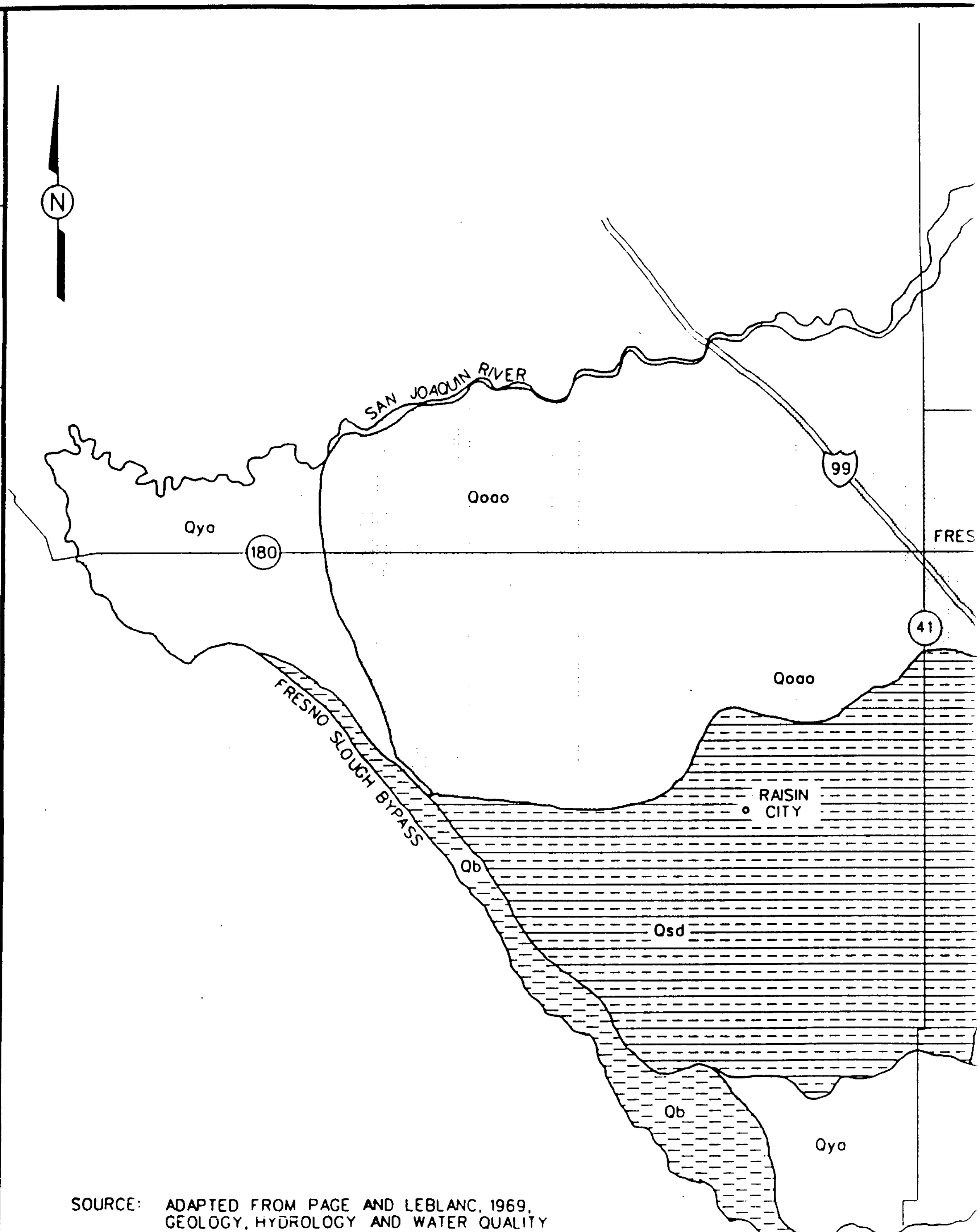

SOURCE: ADAPTED FROM PAGE AND LEBLANC, 1969, GEOLOGY, HYDROLOGY AND WATER QUALITY IN THE FRESNO AREA CALIFORNIA. U.S. DEPARTMENT OF THE INTERIOR, GEOLOGIC SURVEY.

STARTING DATE: 04-05-96	DATE LAST REV.:	DRAFT. CHCK BY: C.TUMLIN	INITIATOR: S.LOGAN	DWG. NO.:409724ES.054
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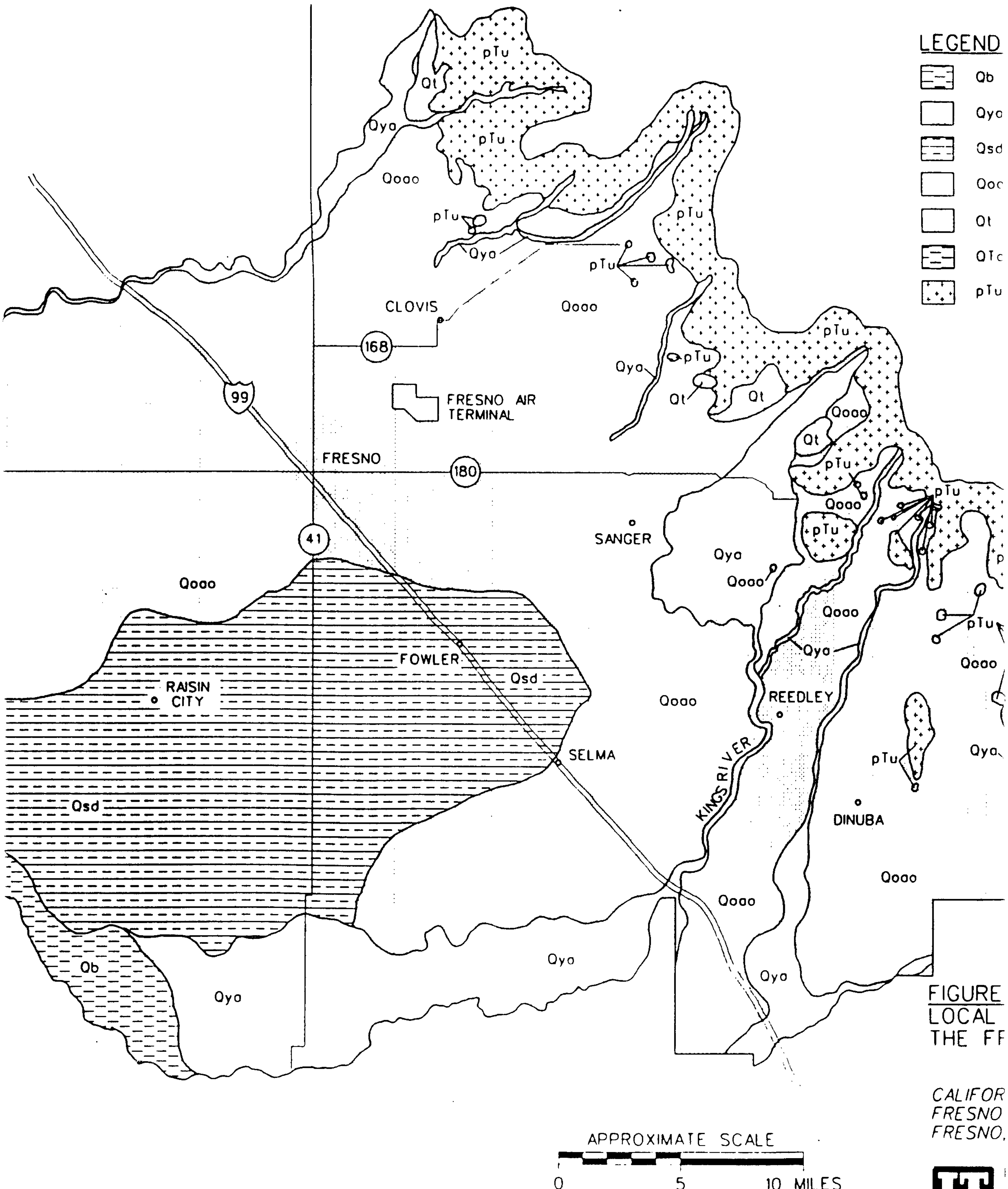

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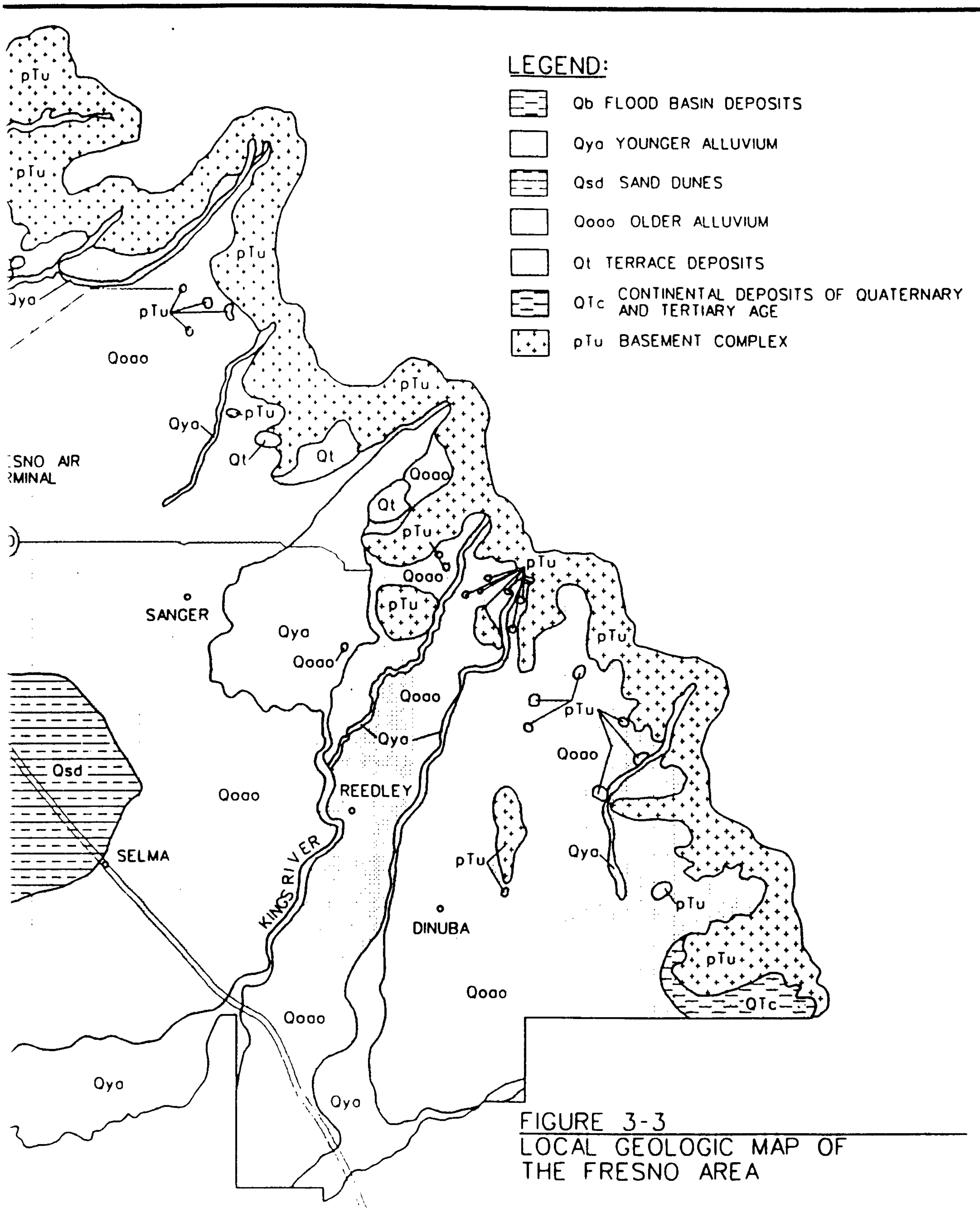

FIGURE 3-3
LOCAL GEOLOGIC MAP OF THE FRESNO AREA

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FRESNO, CALIFORNIA

APPROXIMATE SCALE
0 5 10 MILES

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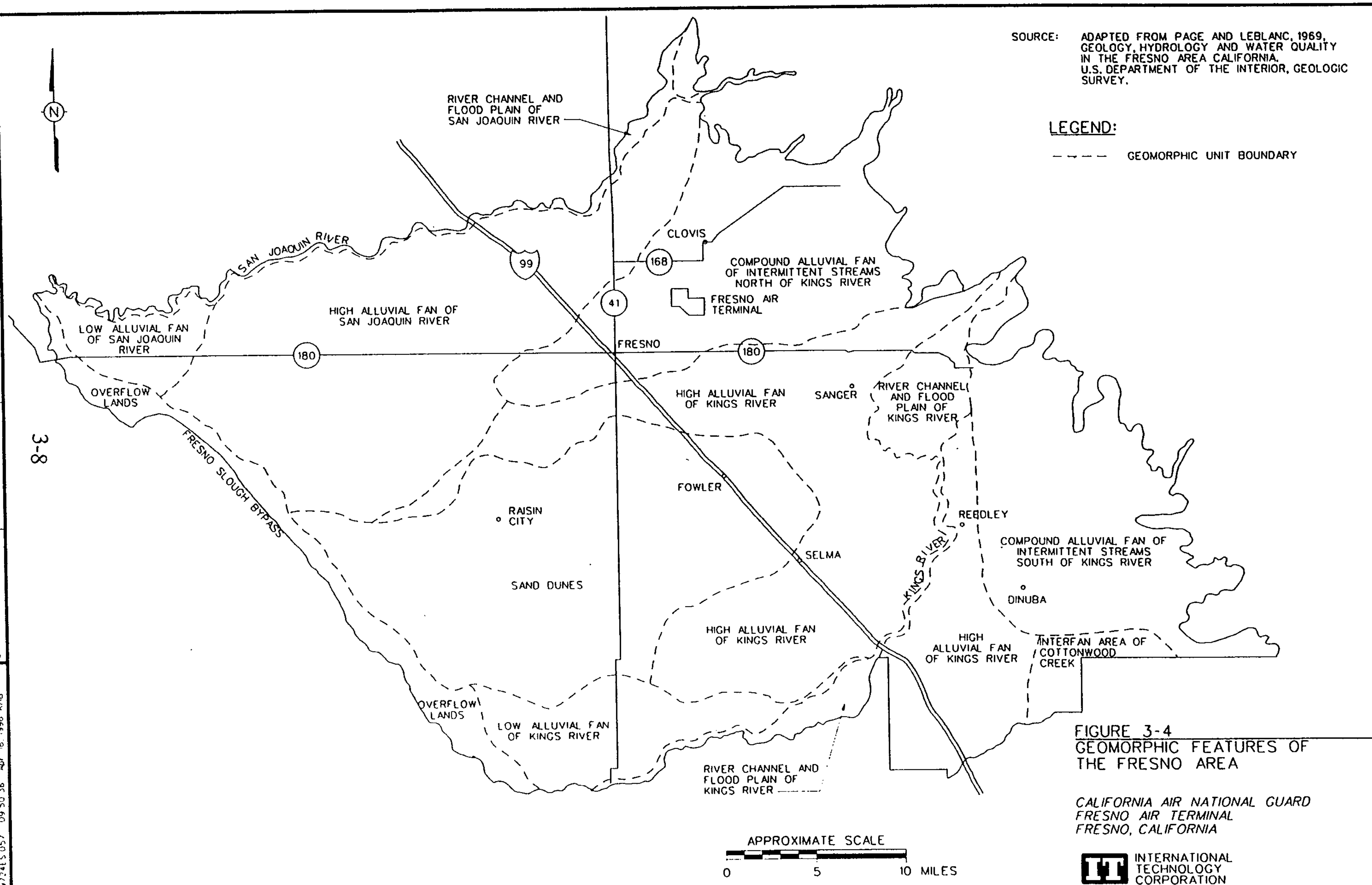

FIGURE 3-4
GEOMORPHIC FEATURES OF THE FRESNO AREA

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FRESNO, CALIFORNIA

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precipitation, glacial depositional environment. The last major depositional episode in the area involved the glaciation of the Sierra Nevada range and deposition of alluvial fans. The fans are the product of glaciation of the Sierra Nevada range that occurred at least 200,000 years ago. Rivers exhibiting braided and meandering stream characteristics deposited and reworked the sediments during the depositional period but became incised approximately 200,000 years ago. Rivers have maintained their current positions for most of the remaining time, providing little additional sediment and having only minimal impact on the character of the fans.

Hydrogeology. The principal fresh-water-bearing units in the Central Valley are the unconsolidated deposits of Pliocene to Recent age that extend to depths of 3,500 feet. Generally, these deposits overlie other units that contain saline water at great depths.

In the eastern portion of the Central Valley, groundwater exists under mainly unconfined or semiconfined conditions within the alluvial fans. These groundwater reservoirs are bounded on the eastern flanks and below by the consolidated Cretaceous and Tertiary sedimentary rocks and Sierra Nevada granitic rocks. The most extensive confined aquifer is overlain by the Corcoran clay, a virtually impermeable clay bed found in lacustrine and marsh deposits of Quaternary age. This clay is encountered between depths of 400 and 800 feet, can vary in thickness from 10 to 160 feet, and covers an estimated area of 5,000 square miles. The Corcoran clay stretches from Highway 99 west to the San Joaquin Valley axis and separates the unconsolidated sedimentary fill into upper and lower sections that have different hydraulic properties. The upper section is unconfined and the lower section was originally confined, but in some areas the potentiometric surface has been lowered by pumping below the base of the confining layer.

The general groundwater flow pattern is from the eastern and western edges toward the center of the Valley and then northward. Yet in many areas, local flows have been altered because of overdraft of aquifer water in agricultural areas. Regionally, groundwater in eastern portions of the Valley flows to the southwest and groundwater in western portions of the Valley flows to the east.

In the western portion of the Valley along the Fresno Slough Bypass, from Kings River north to the San Joaquin River, two basically distinct aquifer systems exist that grade into one another less than 7 miles to the east of the general site area. The upper aquifer is unconfined and occurs in some of the younger alluvium and flood basin deposits, but mostly in the older

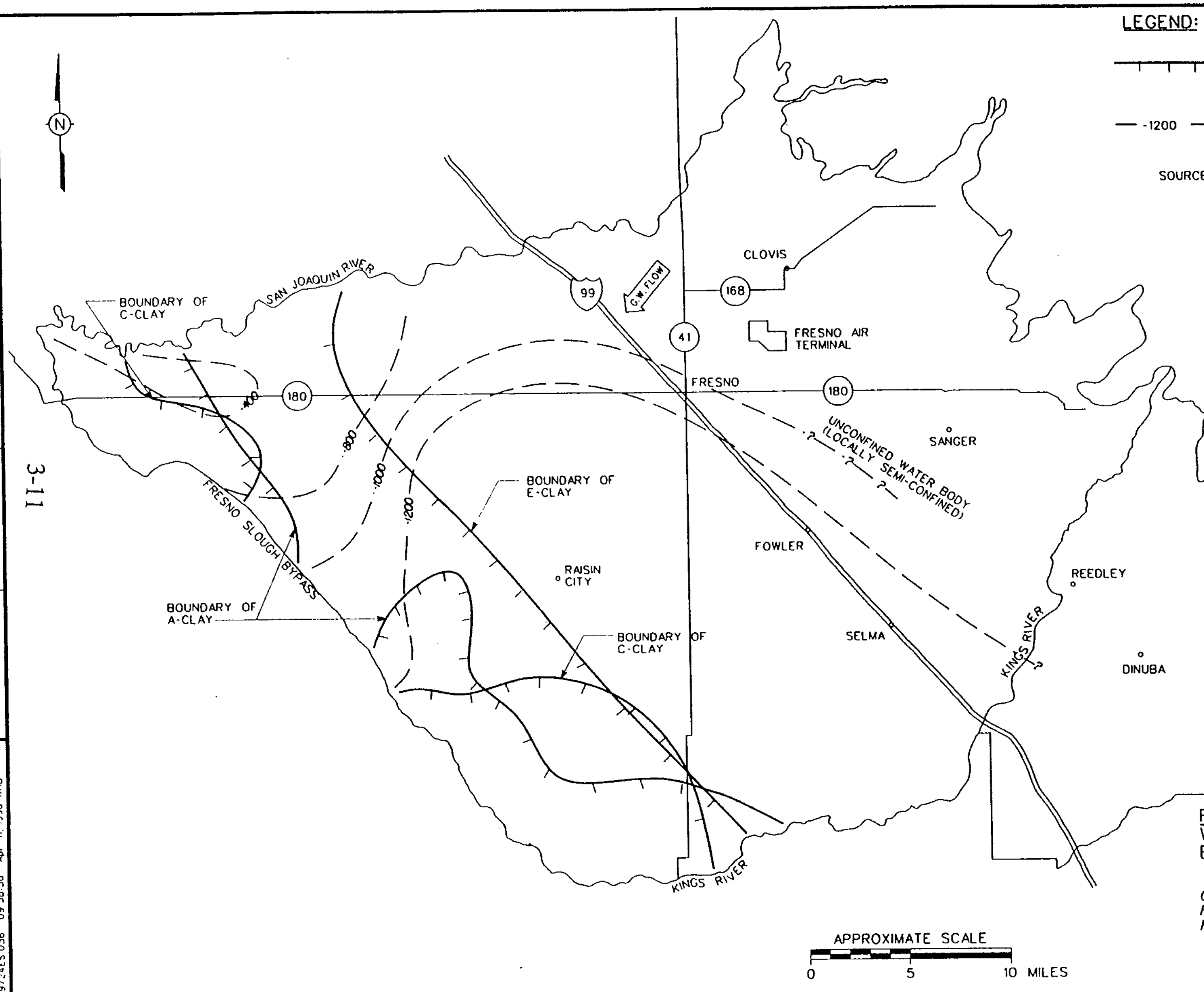
bounded by clay layers of lacustrine and marsh deposits. These clay deposits are a series of almost impermeable clay layers named in order from shallowest to deepest "A" through "E." The layers are thicker and more defined near the Slough Bypass, but pinch out or intermingle toward the east (Figure 3-5). In this confined group, these aquifers have been denoted: one confined below the A-clay, one below the C-clay and one below the E-clay. Figure 3-6 presents a schematic representation of these aquifers.

3.6 Local Geology and Hydrogeology

Geology. Fresno is situated on continental rocks and deposits that are characterized by a mixture of poorly sorted clay, silt, sand, and gravel with some beds of claystone, siltstone, sandstone, and conglomerate of Quaternary and Pliocene ages (Figure 3-3). These generally unconsolidated deposits extend to depths of 1,000 feet or more. In the general site area, geology is characterized by alluvial fan deposits. The fans have low surface relief with gentle slopes. Alluvial fan deposits are heterogeneous both vertically and laterally. Alluvial fans near the site exhibit a wide variety of depositional processes (primarily glacial), alluvial deposits with variable lateral and vertical extents, and multiple source areas and shifting streams to transport, distribute, and deposit material (Cehrs, et al., 1979). Therefore, beds beneath the general site area are localized in extent.

Coarse-grained sediments near the Base occur generally in northeast-southwest trending sand bodies resulting from deposition in stream channels that have shifted over time. Cehrs, et al. (1979) identifies three stratigraphic units in the area of the Base: the Modesto, Riverbank, and the Turlock Lake Formations. The Modesto and Riverbank Formations are surficial, occupying approximately the first 30 feet below ground surface (bgs). The Turlock Lake Formation is described by Cehrs to a depth of approximately 100 feet bgs at the Leaky Acres Recharge Facility, which is approximately 2 miles northwest of the Base.

The Base is located on the Fresno alluvial fans, which are low-angle glacial outwash fans that have deposited and reworked sediments transported largely from the Sierra Nevada (Figure 3-4). Cehrs, et al. (1979) describes the nature of near-surface sediment in the region at a site located near the Base. The Cehrs publication provides a comprehensive summary of regional geomorphology, geology, and hydrology as well a summary of stratigraphy, lithology, and interpreted depositional environments of the geologic section.



LEGEND:

BOUNDARY OF CONFINED OR SEMICONFINED GROUNDWATER

-1200 CONTOURS ON APPROXIMATE BASE OF FRESH WATER WHERE DISSOLVED SOLIDS CALCULATED AS SODIUM CHLORIDE APPROACH 2,000 mg/L CONTOUR INTERVAL, 200 FEET; DATUM IS MEAN SEA LEVEL.

SOURCE: ADAPTED FROM PAGE AND LEBLANC, 1969, GEOLOGY, HYDROLOGY AND WATER QUALITY IN THE FRESNO AREA CALIFORNIA. U.S. DEPARTMENT OF THE INTERIOR, GEOLOGIC SURVEY.

FIGURE 3-5
WATER BODIES AND FRESH WATER BASE CONTOURS - FRESNO AREA

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IT INTERNATIONAL TECHNOLOGY CORPORATION

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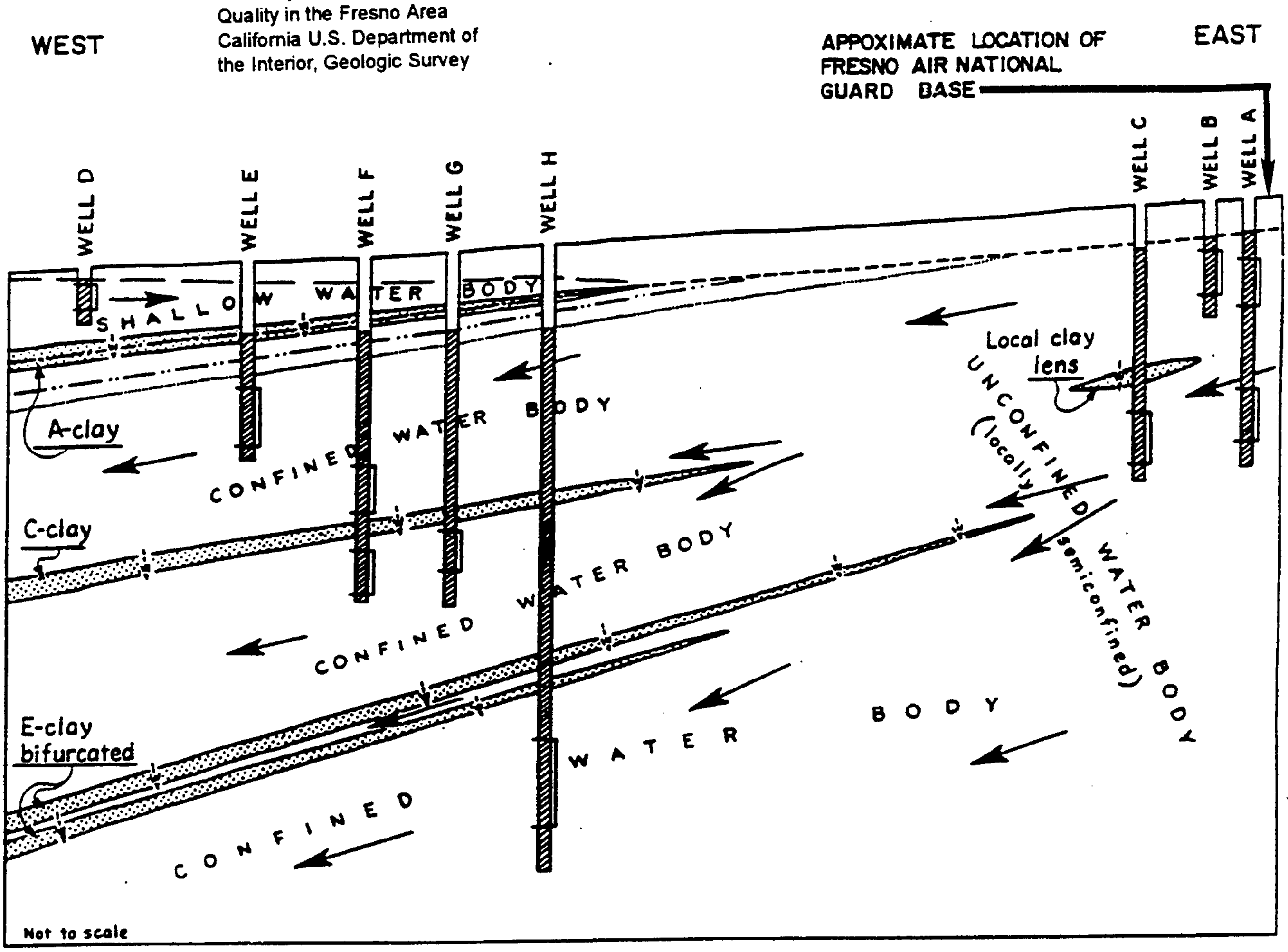
Source: Adapted from Page and Le Blanc, 1969, Hydrology and Water Quality in the Fresno Area California U.S. Department of the Interior, Geologic Survey



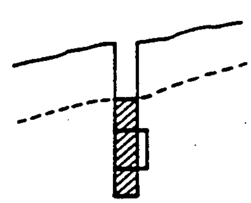
LEGEND

- WATER LEVEL IN THE SHALLOW WATER BODY (WELL D)
- WATER LEVEL IN THE UNCONFINED WATER BODY (WELLS A & B)
- POTENTIOMETRIC SURFACE OF THE CONFINED WATER BODY BETWEEN A- AND C-CLAYS (WELL E)
- POTENTIOMETRIC SURFACE OF THE CONFINED WATER BODY BETWEEN C- AND E-CLAYS (WELL G)
- POTENTIOMETRIC SURFACE OF THE CONFINED WATER BODY BELOW THE E-CLAY (WELL H)
- DIRECTION OF GROUND WATER MOVEMENT
- DIRECTION OF GROUND WATER MOVEMENT THROUGH THE A-, C-, AND E- CLAYS (NOT CONSIDERING EXCESS PORE PRESSURE)

WELL C REFLECTS WATER LEVEL IN A SEMI-CONFINED WATER BODY

WELL F REFLECTS A COMPOSITE POTENTIOMETRIC SURFACE

WELL SYMBOL



TOP OF HATCHING INDICATES WATER LEVEL IN WELLS. BRACKET INDICATES PERFORATED INTERVAL.

FIGURE 3-6

DIAGRAMMATIC GROUND WATER SECTION - WESTERN FRESNO AREA

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

DRAWING NO.: 409724-A-G69 | PROJECT NO.: 409724
INITIATOR: S.LOGAN | PROJ. MGR. D.BURTON
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 08/27/91 | DRAWN BY: C.K.ROBERTSON

BRUNING 72425

Hydrogeology. In the Fresno area, all municipal and rural domestic water is pumped from the alluvial aquifers. The aquifer system has been described as unconfined or semiconfined depending on local hydrogeologic conditions (Cehrs, et al., 1979; Steele, 1986). In 1987, the water table beneath Fresno was 60 to 80 feet bgs, sloping generally to the southwest (California Department of Water Resources, 1987). Groundwater flow through the alluvial sediments comprising the aquifer system is controlled by the slope of the water table (to the southwest) and the occurrence of coarse-grained sediments within the alluvial fans. Coarse-grained sediments within fan deposits occur generally in northeast-southwest trending sand bodies resulting from deposition in ephemeral stream channels that have shifted through time (Cehrs, et al., 1979). Thus, in the Fresno area, groundwater flows generally to the southwest and preferentially through coarse-grained channel deposits.

4.0 Field Program

4.1 Summary

The RI field program consisted of four general field events, and comprises all the activities conducted following the completion of the SI report (IT, 1992a) in February 1992. As recommended in the SI report (Section 2.4.2), the investigation of Site 5-BCP was developed and conducted, and the quarterly groundwater sampling and monitoring program was performed. The Site 5 RI was conducted from August through October 1992. Quarterly groundwater sampling was performed from June 1992 to April 1993, with water level monitoring conducted monthly from June 1992 to May 1993. As a result of the Site 5-BCP investigation, the initial deep aquifer investigation was developed and was conducted from October through December 1993. Following the evaluation of the data from the deep aquifer investigation, pumping tests were conducted at the Base in March 1995. The following sections describe the details of each of these activities, their objectives, and their rationale.

4.2 Site 5-BCP RI

The SI identified the need to investigate the BCP as a potential source of groundwater contamination. The BCP was incorporated into the IRP as Site 5. As recommended in the SI report, the specific objectives of the investigation were to:

- Supplement and refine the existing geologic, hydrogeologic, and geochemical data for the Base.
- Determine the presence of suspected contamination in the subsurface at Site 5-BCP.
- Determine the nature and extent of any confirmed contamination.
- Identify potential on-Base source(s) of known PCE in groundwater exiting the western portion of the Base by using SOV techniques and by installing soil borings and monitoring wells.

The RI activities were divided into screening and confirmation activities. Screening activities consisted of:

- Conducting a SOV survey across the western portion of the Base
- Collecting soil screening samples
- Collecting borehole groundwater screening samples
- Conducting gas chromatograph (GC) analysis in a field laboratory setting.

Confirmation activities comprised:

- Drilling and sampling soil borings
- Collecting soil samples for fixed-base laboratory analysis
- Installing and sampling monitoring wells.
- Other activities.

Table 4-1 summarizes the types and number of samples collected and their analytical parameters for the RI at Site 5-BCP. Field activities followed the procedures specified in the remedial investigation addendum to the SI SAP (IT, 1992b).

4.2.1 Site 5-BCP Field Screening Activities

The screening activities were designed to produce Level B type data (HAZWRAP designation), which provide relative indicators that necessitate and control subsequent tasks. Level B analyses include field techniques that consist of portable analytical instruments (e.g., field GCs) that require standards, calibration, and a trained operator. These methods are analyte-specific and quantitative. Preliminary data gathering in the form of a SOV survey at Site 5 was initiated before any subsurface soil samples were collected. In addition, an interactive screening program involving soil screening samples was conducted to determine those areas requiring confirmation sampling. The following sections describe the purpose, procedures, and events in each screening activity.

Prior to the beginning of screening activities, an earthen ramp was constructed to the bottom of Site 5-BCP to allow access to heavy equipment and vehicles. Once this was constructed, the SOV surveying and predrilling activities began.

4.2.1.1 Soil Organic Vapor Survey

A total of 80 gas samples were collected and analyzed in a mobile laboratory on Base. Each sample was analyzed for the following parameters:

- Benzene
- Trichloromethane
- Toluene
- TCE
- Ethyl benzene
- PCE
- Total xylenes.

Table 4-1

Summary of Remedial Investigation Activities at Site 5-BCP California Air National Guard - Fresno, California

Activity	Number of Samples Analyzed	Analytical Parameters[a]	Analytical Methods
SOV Survey Shallow samples Deep samples	 43 37	 VOC, selected list[b] VOC, selected list[b]	 Modified 8010[c] Modified 8010[c]
Soil Screening Samples	167	VOC, selected list[d]	Modified 5030/601[d]
Borehole Water Screening Samples	7	VOC	8010/8020
Soil Borings, total of 12	41	VOC SVOC TPH-d	8010/8020 CLP[e] Modified 8015
Monitoring wells, total of 2 (MW5-01, MW5-02)	Refer to Table 4-4[f]	VOC SVOC Pesticides/PCBs	8010/8020 CLP CLP
Supplemental Base Perimeter monitoring wells, total of 4 (MWBP-09 through MWBP-12)	Refer to Table 4-4[f]	VOC SVOC Pesticides/PCBs	8010/8020 CLP CLP

[a]VOC - Volatile organic compounds.
SVOC = Semivolatile organic compounds.
TPH-d = Total petroleum hydrocarbons, as diesel.
PCBs = Polychlorinated biphenyls.
[b]Refer to Section 4.2.1.1.
[c]Analyzed on gas chromatograph in a mobile laboratory.
[d]Refer to Appendix A; analyzed on field gas chromatograph.
[e]CLP - Contract Laboratory Program.
[f]Included in quarterly groundwater sampling program.

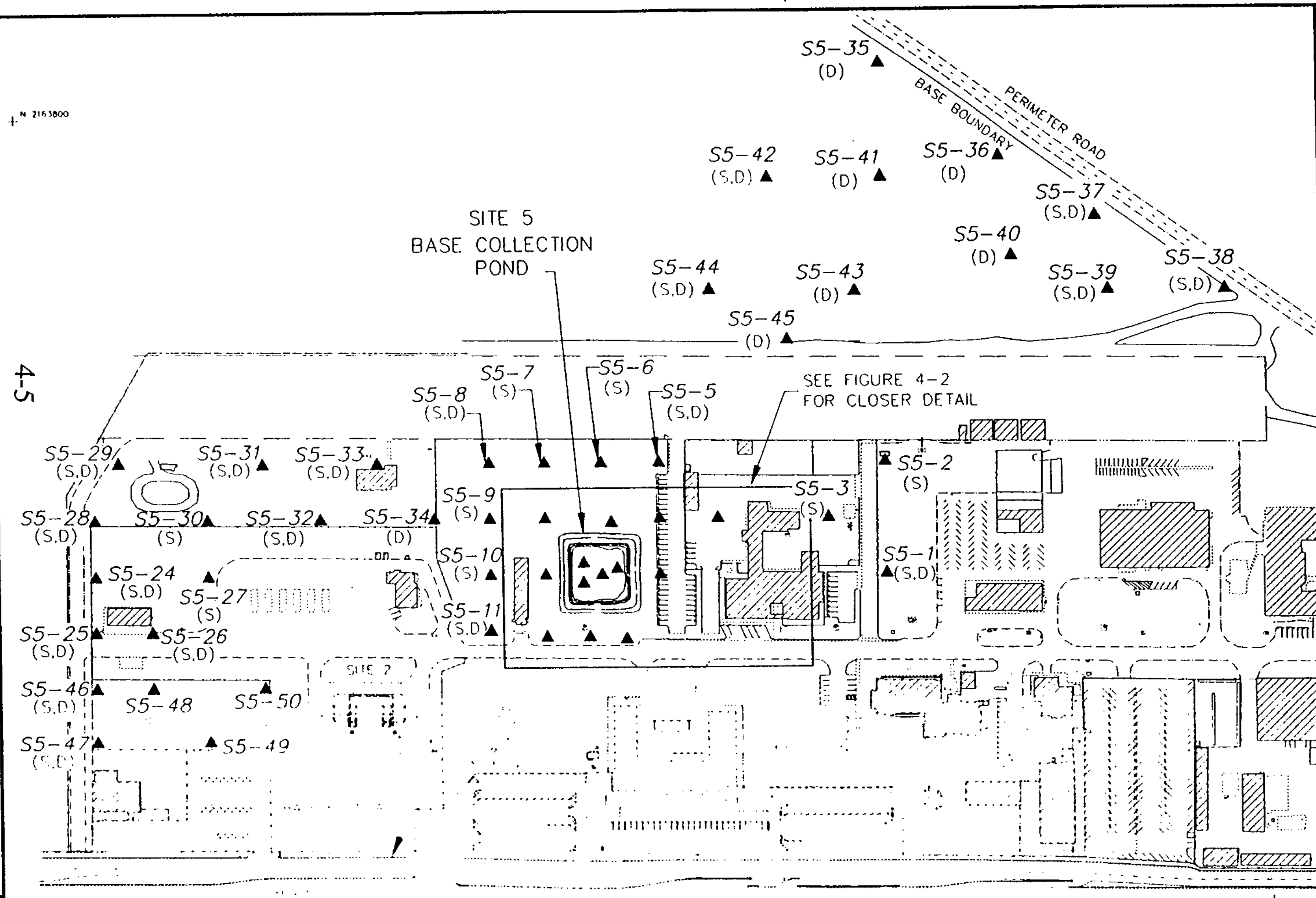
Sampling procedures consisted of driving a hollow steel pipe with a detachable bottom tip into the ground to depths from 5 to 21 feet. To facilitate the driving of the SOV rods, a drill rig was used to puncture a hardpan layer encountered from depths of 4 to 6 feet bgs, and extending to as deep as 18 feet bgs. An initial, or upper, SOV sample was collected at depths ranging from 3 to 6 feet. In some areas, due to extreme soil compaction, it was necessary to drill to 5 feet before the initial sample could be collected. At some locations, the upper sample could not be collected even after the initial drilling had been done, due to soil compaction.

After the first sample was collected at a location, the hole was drilled through the hardpan and a second, deeper sample was collected after the drive rod had been pushed 1 to 2 feet beyond the bottom of the predrilled borehole. Hollow-stem auger drilling techniques were used to penetrate through the hardpan. It is understood that brief excessive heat may have been created through the drilling process. However, the length of time that augers were at the bottom of each hole was minimal, such that minimal temperature increases would have occurred. SOV sample rods were pushed beyond the bottom of the predrilled hole, beyond the extent of any heat-affected soil. This effect is not quantifiable, but is considered negligible for these reasons. Deeper samples were collected at depths ranging from 15 to 21 feet bgs. Figures 4-1 and 4-2 show the placement of the SOV sampling locations.

Polyethylene tubing attached to a hand-held vacuum pump was fitted to the rod and a purge volume of 2 to 5 liters of soil gas was evacuated. A charcoal tube was fitted to the end of the tubing and 1 to 2 additional liters of air were pulled through the charcoal. The tube was then extracted with methanol to desorb any captured organic chemicals. The sample extract was then injected into a GC in a mobile laboratory. Results were obtained on a computing integrator linked to a computer.

The following SOV samples were collected and analyzed:

- Forty-three shallow samples (above the hardpan)
- Thirty-seven deep samples (below the hardpan)
- Two quality control (QC) samples
- One ambient air (background) sample.



LEGEND:

▲S5-40 SOV SAMPLING POINT

(S) SHALLOW SAMPLE COLLECTED BETWEEN 3 AND 8 FEET

(D) DEEP SAMPLE COLLECTED BETWEEN 15 AND 21 FEET

SCALE:

0 200 400 FEET

FIGURE 4-1
REMEDIAL INVESTIGATION
FIELD SCREENING LOCATIONS
ASSOCIATED WITH SITE NO. 5,
BASE COLLECTION POND

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FRESNO, CALIFORNIA

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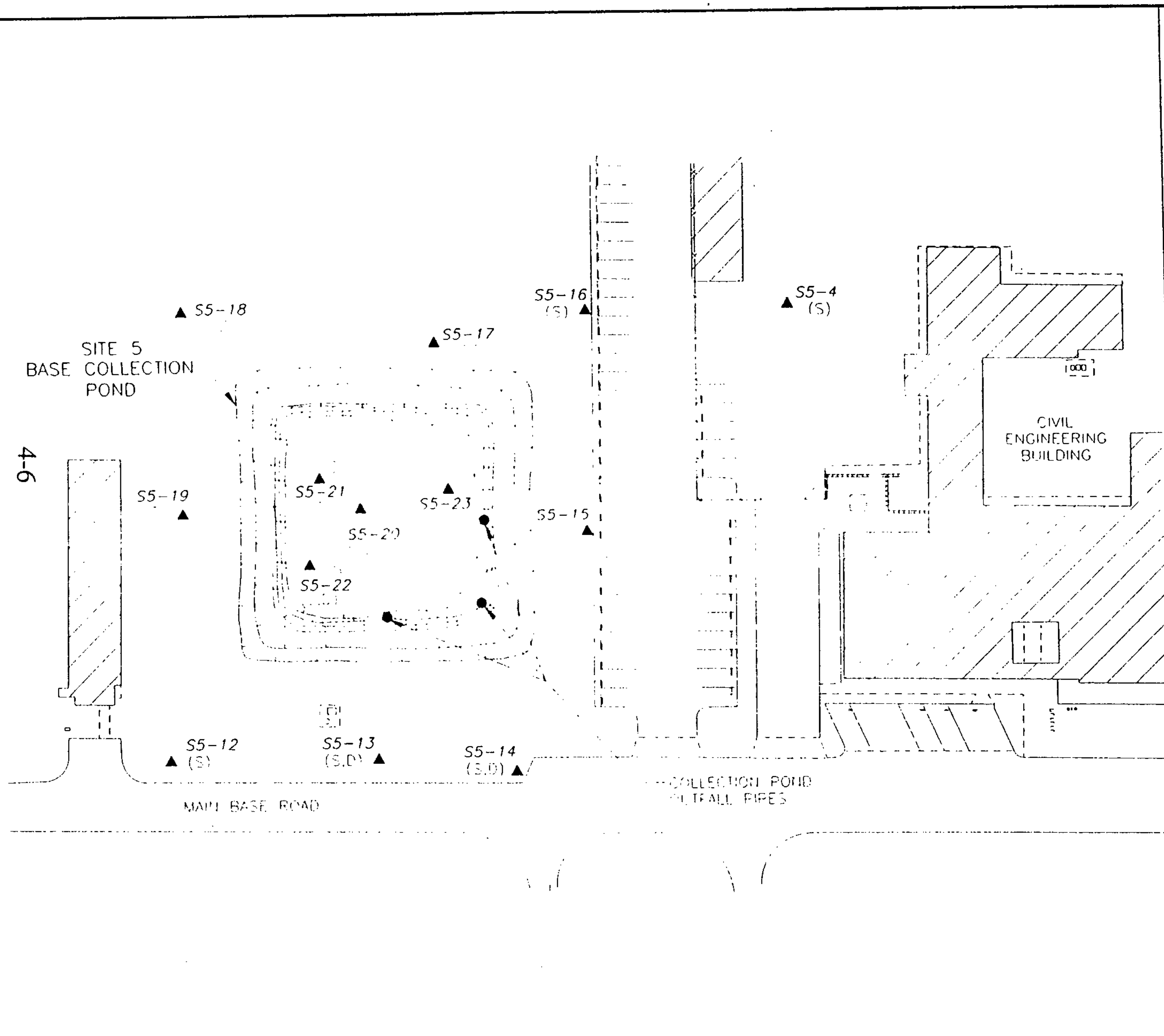
DRAWN BY C ROBERTSON	DRAWN BY	ENGR CHCK BY S LOGAN	PROJ MGR D BURTON	PROJ NO 409724



LEGEND:

- ⊙ DRY WELL LOCATION
- S5-4 ▲ SOV SAMPLING POINT
- (S) SHALLOW SAMPLE COLLECTED BETWEEN 3 AND 8 FEET
- (D) DEEP SAMPLE COLLECTED BETWEEN 15 AND 21 FEET

SCALE: 0 50 100 FEET

FIGURE 4-2
REMEDIAL INVESTIGATION
FIELD SCREENING LOCATIONS
AT SITE NO. 5,
BASE COLLECTION POND

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DRAWN BY PJONES	DRAWN BY	ENGR CHCK BY S LOGAN	PROJ MGR D BURTON	PROJ NO 409274 020 01

7240137 DWG 04/17/96 8 16 AM KHB

4.2.1.2 Site 5-BCP Soil Screening Samples

Soil screening samples were collected from 12 soil borings located in and around Site 5-BCP. As the boreholes were advanced, soil samples were collected for field GC analysis. Confirmation samples were collected from the same sampling device(s) (Section 4.2.2.1).

Soil samples were collected at a minimum frequency of once per 5-foot interval in each borehole, and screened with a GC in a field laboratory setting. The exception to this was boring SB5-12, which was screened once every 10 feet because it was located away from the suspected source area. A maximum of four samples were submitted to the fixed-base laboratory for confirmation analysis for a broader suite of analytical parameters. Criteria for selecting confirmation soil samples are discussed in Section 4.2.2.1.

Soil screening results were used to assist in selecting those samples that would be submitted for confirmation analysis. Screening results are presented in Section 6.2.1.3.

4.2.1.3 Borehole Water Samples

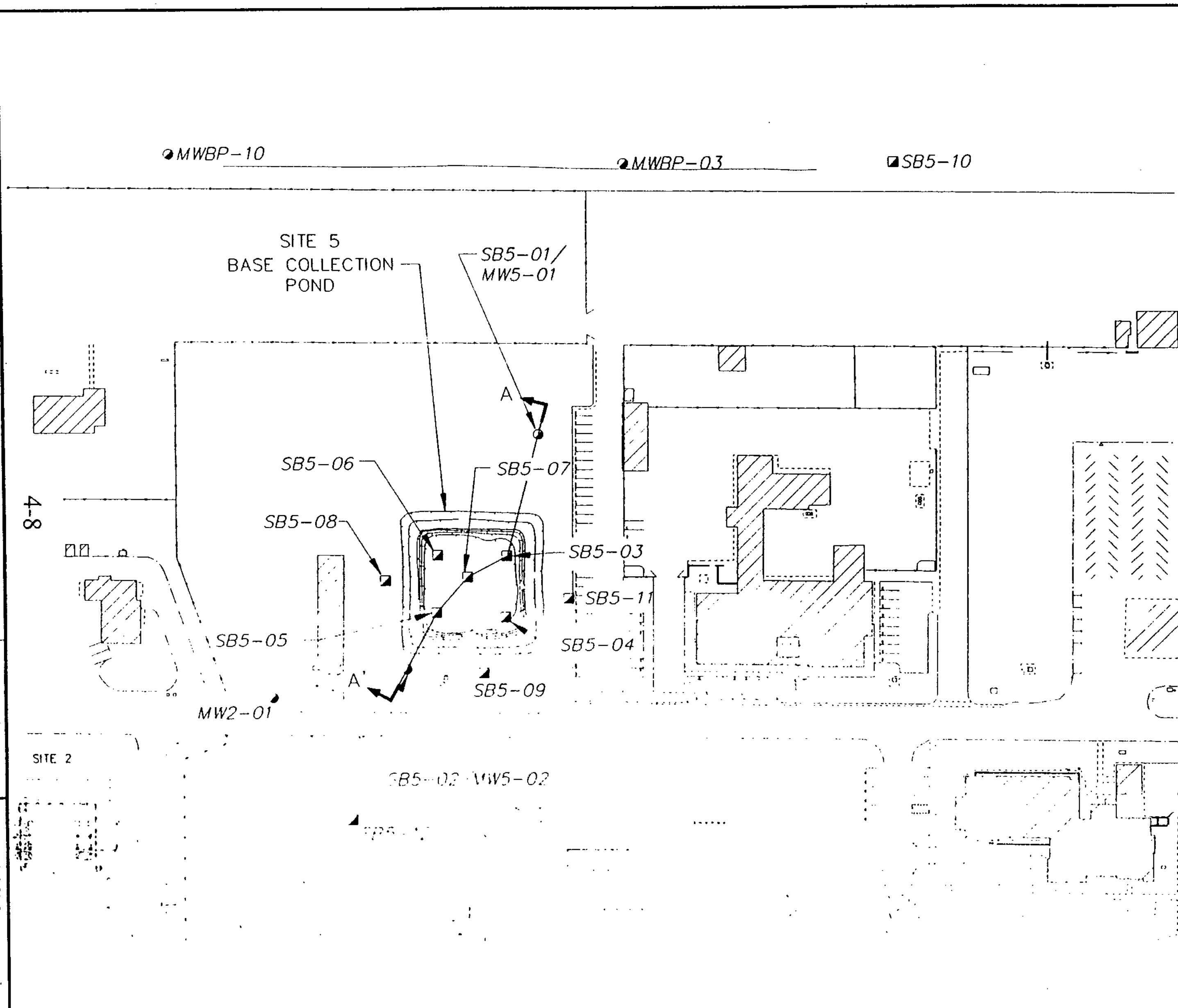
As the field investigation progressed, it was determined necessary to collect groundwater samples from soil borings around Site-BCP to better define groundwater quality in the immediate vicinity. These samples can be considered "grab" samples. Groundwater screening (grab) samples were collected from the bottom of the following boreholes: SB5-01, SB5-02, SB5-08, SB5-09, SB5-10, SB5-11, and SB5-12 (Figure 4-3).

These grab samples were considered screening samples because they were not collected from a properly constructed monitoring well nor was the customary volume of water purged prior to collection. Once the augers had drilled 2 to 4 feet into the water table, the augers were raised off the borehole bottom. Water was allowed to invade the open borehole and a sample was collected with a Teflon™ bailer. Samples were analyzed for volatile organics by Methods 8010/8020 at a fixed-base laboratory.

4.2.1.4 Site 5-BCP Field Gas Chromatograph Analysis

A GC in a field laboratory setting was used to meet two objectives:

- Provide screening data on soil samples from the soil borings along the entire length of the borehole.
- Determine the method of disposal, or the need for further characterization of soil cuttings from all monitoring well boreholes and soil borings.



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LEGEND:

MWBP-03 MONITORING WELL

SB5-10 SITE 5 SOIL BORING LOCATION

A' A CROSS SECTION LOCATION

SCALE:

0 100 200 FEET

FIGURE 4-3
REMEDIAL INVESTIGATION
SOIL BORING LOCATIONS AT
SITE NO. 5, BASE COLLECTION POND

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DRAWN BY: D JONES	DRAWN BY:	ENGR CHCK BY: S LOGAN	PROJ MGR: D BURTON	PROJ NO 409724

The GC was used to screen soil samples for chlorinated VOCs. Soil samples from 5-foot intervals, at a minimum, were screened with the field GC. Results of the GC runs were used to select soil samples to be shipped to the laboratory for confirmation analysis. Soil samples were kept on ice in a cooler until it was determined which samples were to be shipped. Holding times for sample extraction were strictly tracked to ensure that analytical integrity would not be compromised. Field laboratory equipment, calibration, analysis procedures, and sample tracking are summarized in Appendix A.

In addition to providing contaminant concentration screening data, the GC was used as a decision-making tool on the disposition of soil cuttings generated during the field effort. Screening data from the vertical profile of the soil borings were used as a basis for determining the disposition of investigation-derived waste (IDW). The criteria for determining the method of disposal are outlined in the focused RI addendum to the SAP (IT, 1992b).

4.2.2 Site 5-BCP Confirmation Activities

The confirmation activities at Site 5-BCP consisted of a series of soil borings and monitoring wells with soil and groundwater sampling. The following sections discuss the methods, equipment, and other protocol used during these confirmation activities. Results from the sampling program and other field operations are presented in Section 6.2.

4.2.2.1 Site 5-BCP Soil Borings

Soil borings were drilled and sampled at locations within and surrounding Site 5 to provide chemical and geologic information for determining the presence or absence of contamination, and subsurface conditions that affect the occurrence and/or migration of contaminants. Nine soil borings were initially drilled and sampled. Five borings were located in the bottom of the BCP (SB5-03 through SB5-07) near the old dry well locations. It is thought that had any contamination been introduced into the BCP, these infiltration wells would have aided in dispersing the contaminants to the subsurface. Therefore, borings SB5-03 through SB5-07 had the greatest potential for identifying potential contamination. Four borings (SB5-01, SB5-02, SB5-08, and SB5-09) were located outside the BCP's perimeter to collect information on the lateral extent of any soil contamination. One was positioned hydraulically (hydrogeologically) upgradient and three hydraulically downgradient.

After reviewing the GC and groundwater screening data, it was determined that additional borings were needed to meet the objective of full characterization with respect to both soil

and groundwater contamination at Site 5. Three borings (SB5-10 through SB5-12) were drilled and sampled to satisfy this need. These three borings were drilled primarily to collect a groundwater screening sample in key areas between existing monitoring wells. SB5-10 was located further upgradient from SB5-01, and SB5-12 was located the furthest downgradient of all borings. SB5-11 was located on the eastern perimeter of the BCP. All soil boring locations are shown in Figure 4-3.

Soil borings were drilled using a CME-75 drill rig with 6-inch outside diameter (OD) hollow-stem augers. Two types of sampling devices were used. A standard 18-inch-long, 2-inch OD split-spoon sampler was used in highly compacted soil zones. A 5-foot-long, 3.5-inch OD split-barrel sampler was used in less resistant zones. The split-barrel sampler was fitted inside the augers and was set to be 2 to 4 inches in front of the lead auger so that it would collect a relatively undisturbed sample. Each soil boring was advanced to the water table. Total depths of the borings, therefore, ranged from 65 feet in the borings at the bottom of the BCP to 80 feet in the borings outside the BCP.

Soil samples were collected for screening and laboratory chemical analysis; remaining soil from the sampling device was visually logged. Soil samples were collected with either the 18-inch-long sampler or with the split-barrel sampler. Both devices were fully lined with 6-inch-long brass sleeves.

When the 18-inch sampler was used, the bottom sleeve was transferred to the field GC for screening analysis. The middle sleeve was retained for possible laboratory submittal (confirmation analysis), and the top sleeve was discarded after logging any remaining soil. When the 5-foot sampler was used, the bottom two sleeves were capped for screening and laboratory analysis. In addition, two other adjacent sleeves from the middle of the 5-foot split-barrel sampler were capped. These two samples were stored for any additional screening analysis if results indicated that an additional analysis would provide better sampling coverage.

All samples collected for analysis were logged in and their custody was tracked through disposal or shipment. Selected soil samples were sent to IT's laboratory (now known as Quanterra Environmental Services, Inc. [Quanterra]) in Knoxville, Tennessee for analysis. Tested parameters for all confirmation soil samples were VOCs, SVOCs, and total petroleum hydrocarbons (TPH) in the diesel, or high boiling, range (TPH-d).

Soil borings within the BCP were continuously sampled with the 5-foot split-barrel sampler. Sufficient recovery was obtained due to the moisture content softening the soil. The remaining borings were sampled primarily with the standard 18-inch sampler. When recovery from the 5-foot barrel was poor in the first boring drilled outside the BCP, sampling switched to the 18-inch-long split-spoon sampler. Poor recovery was caused by soil compaction, hardpan, and the variety of sand layers encountered. Sand tended to form a consolidated block in the bottom portion of the split-barrel sampler that prevented any other soil material from entering the barrel. Samples collected with the 18-inch sampler were taken at 5-foot depth intervals.

The primary decision-making tool used for selecting confirmation samples to be sent to the fixed-base laboratory was the field GC. In general, two soil samples were selected from zones showing elevated VOC concentrations in the screening analysis. The soil sample from the bottom of the borehole (i.e., just above the water table) was also sent for analysis. The fourth sample was selected based on lithology or other observations noted on the boring logs. Several borings showed moist zones at certain depths. Soil samples were selected either from within this zone or from a fine-grained layer underneath this zone.

If the GC screening results were inconclusive, then soil samples were selected based on lithology alone. Samples targeted were those from within a sand layer, from just above or within a fine-grained (silt) layer, or from near a moist zone. Table 4-2 lists the soil samples submitted to the laboratory and the reasoning behind why they were selected. A total of 37 soil samples were submitted for confirmation analysis. Five field duplicates and three matrix spike duplicate sample sets were also submitted.

Two geotechnical samples were collected from the saturated soil material at the bottom of boreholes SB5-07 and SB5-01. Geotechnical parameters analyzed were vertical permeability, total porosity, grain size with hydrometer, total organic matter content, bulk density, and Atterberg limits. A summary of geotechnical samples collected is provided in Table 4-3.

Two borings were converted into monitoring wells: SB5-01 into MW5-01 and SB5-02 into MW5-02. The 6-inch boreholes were reamed to 12 inches in diameter, and were drilled 10 to 15 feet below the first occurrence of water.

Table 4-2

Soil Samples Selected for Laboratory Submittal at Site 5-BCP and Selection Rationale California Air National Guard - Fresno, California

Soil Boring Identification	Sample Depth (ft)	Date Collected	Selection Rationale[a]
SB5-01	30.5 to 31.0 41.0 to 41.5 49.0 to 49.5 80.5 to 81.0	10/02/92 10/02/92 10/02/92 10/02/92	Upper sample; above cemented zone In cemented zone Above sand layer Bottom of hole
SB5-02	41.0 to 41.5 64.0 to 64.5 72.5 to 73.0 83.0 to 83.5	09/29/92 09/30/92 09/30/92 09/30/92	Upper sample; increased moisture Fine-grained layer Weakly cemented zone; increased moisture Bottom of hole
SB5-03	9.0 to 9.5 19.0 to 19.5 34.0 to 34.5 64.0 to 64.5	09/24/92 09/24/92 09/24/92 09/24/92	Field GC; above weakly cemented zone Field GC; above weakly cemented zone Field GC Field GC; bottom of hole
SB5-04	19.0 to 19.5 29.5 to 30.0 59.0 to 59.5 64.0 to 64.5	09/28/92 09/28/92 09/28/92 09/28/92	Field GC; fine-grained zone Field GC Field GC Bottom of hole
SB5-06	24.0 to 24.5 29.0 to 29.5 39.0 to 39.5 64.0 to 64.5	09/24/92 09/24/92 09/24/92 09/24/92	Field GC; increased moisture Field GC; increased moisture Fine-grained layer Field GC; bottom of hole
SB5-07	17.0 to 17.5 29.0 to 29.5 44.0 to 44.5 64.0 to 64.5	09/25/92 09/25/92 09/25/92 09/25/92	Upper sample; increased moisture Increased moisture Field GC Bottom of hole
SB5-08	30.5 to 31.0 55.5 to 56.0 60.5 to 61.0 85.5 to 86.0	10/05/92 10/05/92 10/05/92 10/05/92	Fine-grained layer Increased moisture Below moisture Bottom of hole
SB5-09	25.5 to 26.0 40.5 to 41.0 70.5 to 71.0 85.5 to 86.0	10/07/92 10/07/92 10/07/92 10/07/92	Upper sample Increased moisture Above fine-grained layer Bottom of hole
SB5-10	15.5 to 16.0 50.5 to 51.0 85.5 to 86.0	10/12/92 10/12/92 10/12/92	Upper sample Above fine-grained layer Bottom of hole
SB5-11	85.5 to 86.0	10/13/92	Bottom of hole
SB5-12	80.5 to 81.0	10/15/92	Bottom of hole

[a]GC - Gas chromatograph (field laboratory analysis showed organics present above detection limits).

Refer to Table 6-3 of this RI report for screening sample results and Table 6-4 for a summary of confirmation sample results.

Table 4-3

Summary of Geotechnical Samples Collected
California Air National Guard - Fresno, California

Investigation Program	Borehole Location	Sample Depth (ft)[a]	Sample Parameters
RI at Site 5	MWBP-09	95	Particle size distribution, porosity, permeability, Atterberg limits, density, organic content
	MWBP-10	90	
	MWBP-11	95	
	MWBP-12	91	
	SB5-01	86	
	SB5-07	66	
Deep Aquifer Investigation	EXB-02	85 (F)	(F): Permeability, porosity, density, organic content
		125 (F)	
		152 (C)	
		238 (F)	
	EXB-03	97 (C)	(C): Particle size distribution, organic content
		128 (F)	
		175 (C)	
		198 (F)	
		209 (F)	
		248 (C)	
	EXB-04	116 (C)	
		138 (C)	
		150 (C)	
		180 (F)	
		206 (C)	
		208 (F)	
	EXB-05	89 (F)	
		167 (F)	

[a](F) = Fine-grained material.
(C) = Coarse-grained material.

4.2.2.2 RI Monitoring Wells

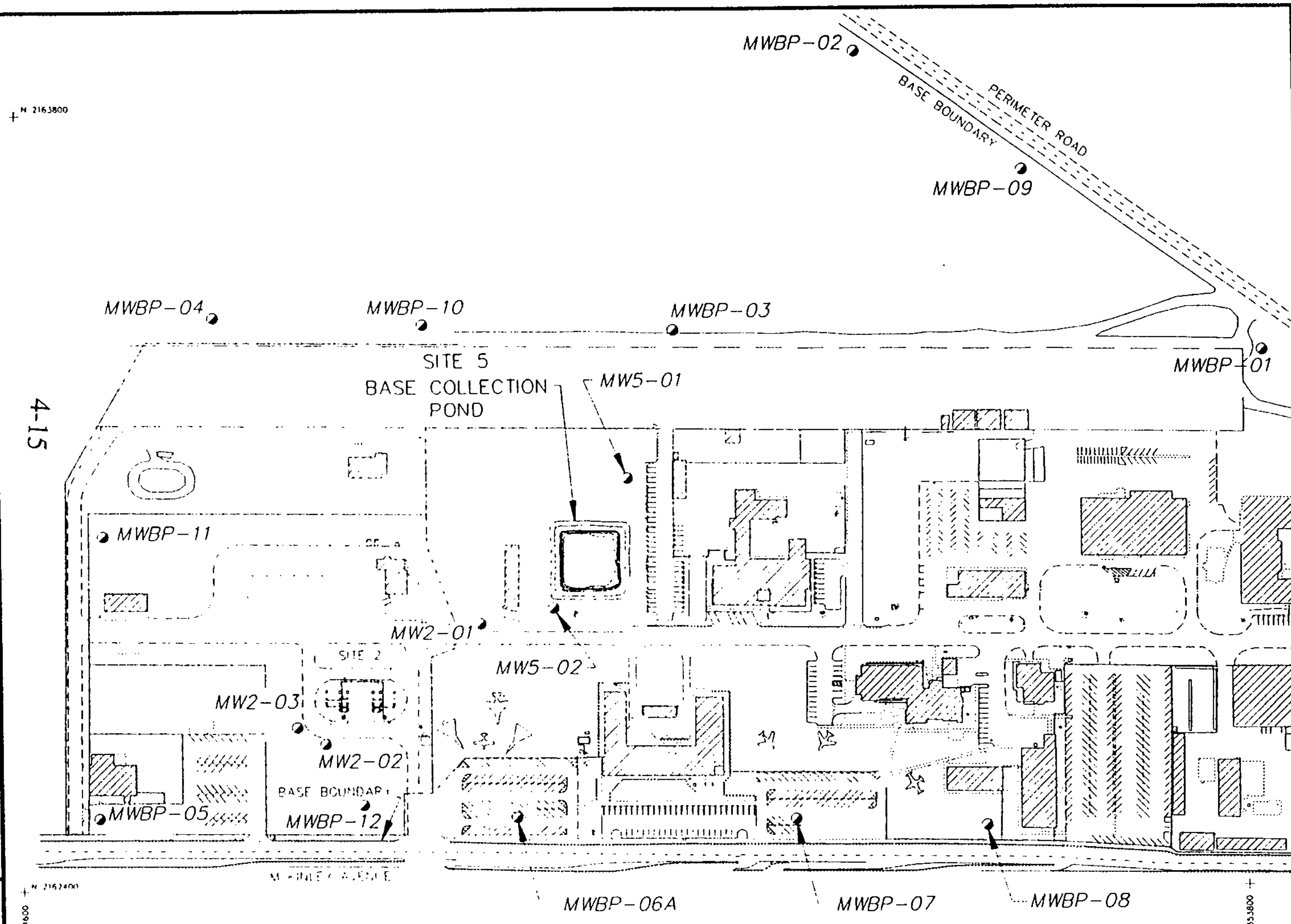
Six groundwater monitoring wells were installed as a part of the RI at Site 5. Monitoring wells were installed in two general areas to monitor groundwater quality of the uppermost water-bearing zone: along the Base perimeter (MWBP-09 through MWBP-12), and at Site 5-BCP (MW5-01 and MW5-02). Well MW5-01 was located approximately 100 feet upgradient and MW5-02 was located immediately downgradient from Site 5-BCP. Another well, MW2-01, which was installed in 1990 during the Site 2 investigation of the SI, is also located immediately downgradient (hydrogeologically) of Site 5-BCP.

Four additional monitoring wells were installed around Base property to supplement the existing database consisting originally of eight perimeter wells. Two of the new wells were placed in the north perimeter field (MWBP-09 and MWBP-10), one was placed on the westernmost Base boundary (MWBP-11), and one was placed on the southern boundary (MWBP-12), directly south of Site 2. These wells are shown in Figure 4-4.

All wells were drilled with 12-inch OD hollow-stem augers. Total depths averaged 94.5 feet bgs, approximately 12 to 15 feet below the water table. Five undisturbed samples from the bottom of the borehole were collected for geotechnical property analyses. Geotechnical parameters were identical to those tested in the soil borings (Section 4.2.2.1). The grain-size data were used to properly size the type of filter pack material and to confirm the well screen slot size.

Each monitoring well borehole was continuously logged for stratigraphic description. Monitoring wells MW5-01 and MW5-02 were initially drilled as soil borings. They were also continuously logged. The boreholes were reamed to 12 inches in diameter, and depths were extended to below the water table.

Well construction consisted of 20 feet of 4-inch inside diameter (ID), 0.010-inch slot, Schedule 40 polyvinyl chloride (PVC) screen flush-threaded with 4-inch ID Schedule 40 PVC casing. Twenty feet of screen was used to accommodate seasonal fluctuations in the water table. The borehole annulus was filled with a 20/40 mesh silica filter sand to a level at least 3 feet above the top of the screen. A minimum 2-foot-thick layer of bentonite pellets was placed on top of the filter pack and was hydrated with potable water. The remainder of the annulus was filled with a cement/bentonite grout to ground surface. All well completion



LEGEND:

MWBP-03 MONITORING WELL

NOTES:
MWBP-01 THROUGH MWBP-08 AND MW2-01 THROUGH MW2-03 INSTALLED IN 1990 MWBP-09 THROUGH MWBP-12, MW5-01 AND MW5-02 INSTALLED DURING RI IN 1992.

SCALE:
0 200 400 FEET

FIGURE 4-4
REMEDIAL INVESTIGATION
MONITORING WELL LOCATIONS

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FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

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materials were emplaced through the auger stem and depths were periodically checked with a weighted nylon tape. A typical well construction diagram is shown in Figure 4-5. Appendix B contains well construction data for all monitoring wells installed at the Base.

Well development occurred no later than 2 weeks after installation. Development consisted of surging the well for approximately 1 hour, followed by steady bailing and surging for another 2 to 3 hours. Final development water was clear with only a small percentage of silt. No filter sand was observed in the purged water after the first 20 to 30 gallons of water were removed.

After initially surging well MWBP-09, a Teflon bailer was lowered into the well. A faulty cross bar came loose from the top of the bailer and the bailer was lost down the well. Several attempts were made to retrieve it with no success. The bailer is 3 feet in length, so it does not block a large portion of the saturated screen interval. It was decided to leave the bailer in the well and develop the well as best as possible, because repeated attempts might have resulted in damaging the well screen. The bailer will not have any adverse effects on sampling results because it is Teflon.

The remaining development on this and other wells was accomplished with a 5-foot long surge block, and a 7-foot-long PVC bailer.

Groundwater samples were collected from each monitoring well installed during the RI according to the procedures established in the SAP (IT, 1990). Casing volumes were calculated from measurements of total well depth and depth to water. Three casing volumes were purged prior to sampling. Field measurements of pH, temperature, and conductivity were collected while purging and sampling to ensure that formation water was being extracted. Samples were analyzed for VOCs, SVOCs, and pesticides/polychlorinated biphenyls (PCB).

Sampling of these monitoring wells was then incorporated into the quarterly sampling program (Section 4.3.2) and the wells were sampled two more times (in January and April 1993).

4.2.2.3 Other RI Activities

Other activities associated with the RI at Site 5-BCP included aquifer testing and land surveying.

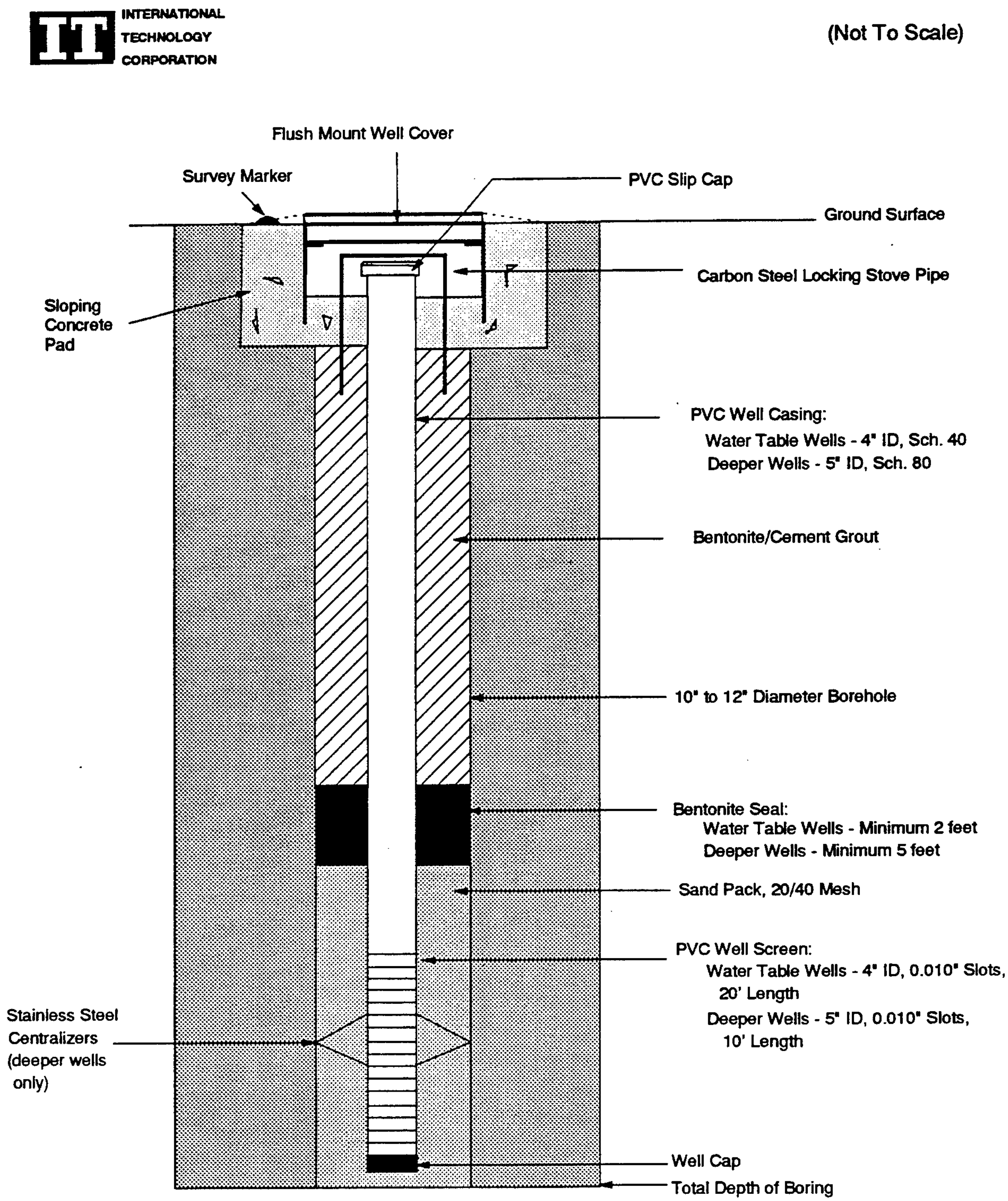


FIGURE 4-5

TYPICAL MONITORING WELL CONSTRUCTION DIAGRAM

California Air National Guard
Fresno Air Terminal
Fresno, California

FRESNO\FIG4-5.drw\mc\10-24-95

Slug tests were performed in all six monitoring wells installed during the RI after they had been developed and sampled. Tests were performed as rising head (slug out) tests by removing a 6-foot-long by 3.5-inch OD PVC slug. The data were analyzed and results are discussed in Section 5.2 and are included in Appendix C.

Each soil boring and monitoring well was surveyed for horizontal coordinates and vertical control. The ground surface and top of PVC well casing were surveyed at each well. A permanent mark was notched into the well casing to ensure consistent measuring points.

4.3 Quarterly Groundwater Sampling Program

A quarterly groundwater sampling program was initiated in 1992 to provide information on the variability and/or stability of the concentrations detected in groundwater samples from the water table monitoring wells. Four sampling rounds were conducted: June/July 1992; October 1992; January 1993; and April 1993. The first round was conducted prior to the Site 5-BCP investigation and the second round was conducted towards the completion of Site 5 investigation activities. Table 4-4 lists the monitoring wells sampled and their respective analytical parameters for the groundwater sampling activities during both the SI and quarterly sampling programs. Groundwater sampling procedures that were used during the SI were used during each of the four quarterly sampling rounds (remove a minimum of three well casing volumes from each well prior to collecting a sample with a Teflon bailer). Only sampling activities associated with Base perimeter wells or Site 5-BCP wells are discussed here.

4.3.1 October 1992

Monitoring wells MW5-01, MW5-02, MWBP-09, MWBP-10, MWBP-11, and MWBP-12 were installed in September and October 1992 in association with the Site 5 investigation (Section 4.2.2). These wells were added to the wells to be sampled during the October 1992 quarterly sampling round. For these six wells, the analytical parameters were specified in the focused RI addendum (IT, 1992b), and are shown in Table 4-4. At the initial eight Base perimeter monitoring wells and the three wells at Site 1, the number of analytical requirements were reduced. Analytical parameters were agreed to by California DTSC.

At the Base perimeter wells, no SVOCs, pesticides, or PCBs had been detected in the three previous sampling rounds. Only VOCs were analyzed at these eight wells in October 1992.

Table 4-4

Summary of Groundwater Sampling Activities for Water Table Wells
California Air National Guard - Fresno, California

Site No.	Well ID	Site Investigation												Quarterly Sampling Program																								Total Number of Sampling Events
		November 1990						February 1991						June/July 1992						October 1992						January 1993						April 1993						
		VOC	SVOC	TPH-d	Pest/PCB	Metals	Lead	VOC	SVOC	TPH-d	Pest/PCB	Metals	Lead	VOC	SVOC	TPH-d	Pest/PCB	Metals	Lead	VOC	SVOC	TPH-d	Pest/PCB	Metals	Lead	VOC	SVOC	TPH-d	Pest/PCB	Metals	Lead	VOC	SVOC	TPH-d	Pest/PCB	Metals	Lead	
1	MW1-01	✓		✓			✓	✓		✓			✓	✓		✓			✓	✓						✓						✓						6
	MW1-02	✓		✓			✓	✓		✓			✓	✓		✓			✓	✓						✓						✓						6
	MW1-03	✓		✓			✓	✓		✓			✓	✓		✓			✓	✓						✓						✓						6
2	MW2-01	✓		✓				✓		✓				✓		✓				✓		✓				✓		✓				✓		✓				6
	MW2-02	✓		✓				✓		✓				✓		✓				✓		✓				✓		✓				✓		✓				6
	MW2-03	✓		✓				✓		✓				✓		✓				✓		✓				✓		✓				✓		✓				6
3	MW3-01A	✓	✓	✓				✓	✓	✓										✓	✓	✓				✓						✓						5
4	MW4-01	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓		✓			✓																			3
	MW4-02	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓		✓			✓																			3
5	MW5-01																			✓	✓		✓			✓						✓						3
	MW5-02																			✓	✓		✓			✓						✓						3
Base background	BMW-1[a]	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓																										2
	BMW-2							✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓				✓		✓				✓		✓				5
Base perimeter	MWBP-01	✓	✓		✓			✓	✓		✓			✓	✓		✓			✓						✓						✓						6
	MWBP-02	✓	✓		✓			✓	✓		✓			✓	✓		✓			✓						✓						✓						6
	MWBP-03	✓	✓		✓			✓	✓		✓			✓	✓		✓			✓						✓						✓						6
	MWBP-04	✓	✓		✓			✓	✓		✓			✓	✓		✓			✓						✓						✓						6
	MWBP-05	✓	✓		✓			✓	✓		✓			✓	✓		✓			✓						✓						✓						6
	MWBP-06A	✓	✓		✓			✓	✓		✓			✓	✓		✓			✓						✓						✓						6
	MWBP-07	✓	✓		✓			✓	✓		✓			✓	✓		✓			✓						✓						✓						6
	MWBP-08	✓	✓		✓			✓	✓		✓			✓	✓		✓			✓						✓						✓						6
	MWBP-09																			✓	✓		✓			✓						✓						3
	MWBP-10																			✓	✓		✓			✓						✓						3
	MWBP-11																			✓	✓		✓			✓						✓						3
	MWBP-12																			✓	✓		✓			✓						✓						3
Number of Samples per Round		18						19						17						22						22						22						

a - Well unusable in Jan. 1992; abandoned in Nov. 1993

VOC - Volatile organic compounds by 8010/8020

SVOC - Semivolatile organic compounds by CLP

TPH-d - Total petroleum hydrocarbons, as diesel

Pest/PCBs - Pesticides/polychlorinated biphenyls by CLP

KN/3069/TBL4-4.XLS(Sheet1)/2/4/97(4:42 PM)/F1/E(2-3-97)

Table 4-4 lists the monitoring wells sampled and their respective analytical parameters for the October 1992 sampling event. A total of 22 wells were sampled.

4.3.2 January 1993

Each well that was sampled in the October 1992 round was sampled in January 1993. Analytical parameters were again reduced based on a lack of detections. Parameters to be analyzed were discussed with and agreed to by the California DTSC and the California Regional Water Quality Control Board (Central Valley Region). Because no SVOCs, pesticides, or PCBs were detected in the samples from the six wells installed during the Site 5-BCP investigation, these parameters were removed from the required analyses. Analytical testing parameters were also reduced based on the fact that the original eight Base perimeter wells had been sampled three times for SVOCs and pesticides/PCBs and no detections had been reported. A total of 22 wells were sampled in January 1993.

4.3.3 April 1993

The sampling program for the April 1993 round remained consistent with the January 1993 sampling round; 22 wells were sampled. No changes between the third and fourth rounds were determined to be necessary. The April 1993 event was the final quarter in which groundwater samples were collected from the shallow (water table) monitoring wells.

4.4 Groundwater Level Measurements

As a part of the quarterly groundwater sampling program, water level measurements were collected monthly from June 1992 through May 1993. Water levels were measured in every well existing on Base at the time of the measurement round. This information was then added to the existing groundwater elevation database to monitor seasonal fluctuations and any changes in general groundwater flow directions.

4.5 Initial Deep Aquifer Investigation

The Site 5-BCP RI adequately characterized the extent of chemical constituents in soil and the lateral extent of VOC contamination in the uppermost water-bearing unit. The vertical extent of groundwater contamination had not been determined, however. This was the primary objective of the initial deep aquifer investigation. Supplemental goals of this investigation were to:

- Supplement and refine the existing geologic, hydrogeologic, and geochemical data for the Base.

- Establish and supplement existing groundwater chemical and water level data at areas in the western portion of the Base.

- Determine the nature and vertical extent of groundwater contamination to a depth of 250 feet bgs.

To determine the vertical extent of groundwater contamination, the following objectives were established:

- Identify sand (permeable) layers beneath the water table that would provide the greatest potential for groundwater and contaminant migration.

- Determine the presence, depths, and continuity of these layers across Base property.

- Determine the concentrations of chlorinated VOCs with depth, focusing on concentrations within the identified sand layers.

- Assess the portion and type of contaminants that could be directly related to the Base, or more specifically to Site 5-BCP.

These objectives were met by developing a program that incorporated detailed subsurface lithologic logging, collecting groundwater screening samples, and analyzing those samples with a field GC. Information thus obtained would provide the data necessary to rationally design a deep monitoring well network through the western portion of the Base. The deep aquifer investigation was conducted in four phases: deep exploratory boring program, field data analysis, monitoring well network design/installation, and sampling according to the initial deep aquifer investigation addendum to the SI SAP (IT, 1993a). Deep aquifer investigation activities were conducted from October to December 1993. A summary of field activities is presented in Table 4-5.

4.5.1 Exploratory Boring Program

The exploratory boring program provided a detailed geologic cross section, contaminant distribution screening, and hydrologic characterization of the deep aquifer. Five exploratory borings, EXB-01 through EXB-05, were drilled to approximately 250 feet bgs using rotary sonic drilling techniques. Borings EXB-01 through EXB-05, located on a southwest-northeast profile, are shown in Figure 4-6.

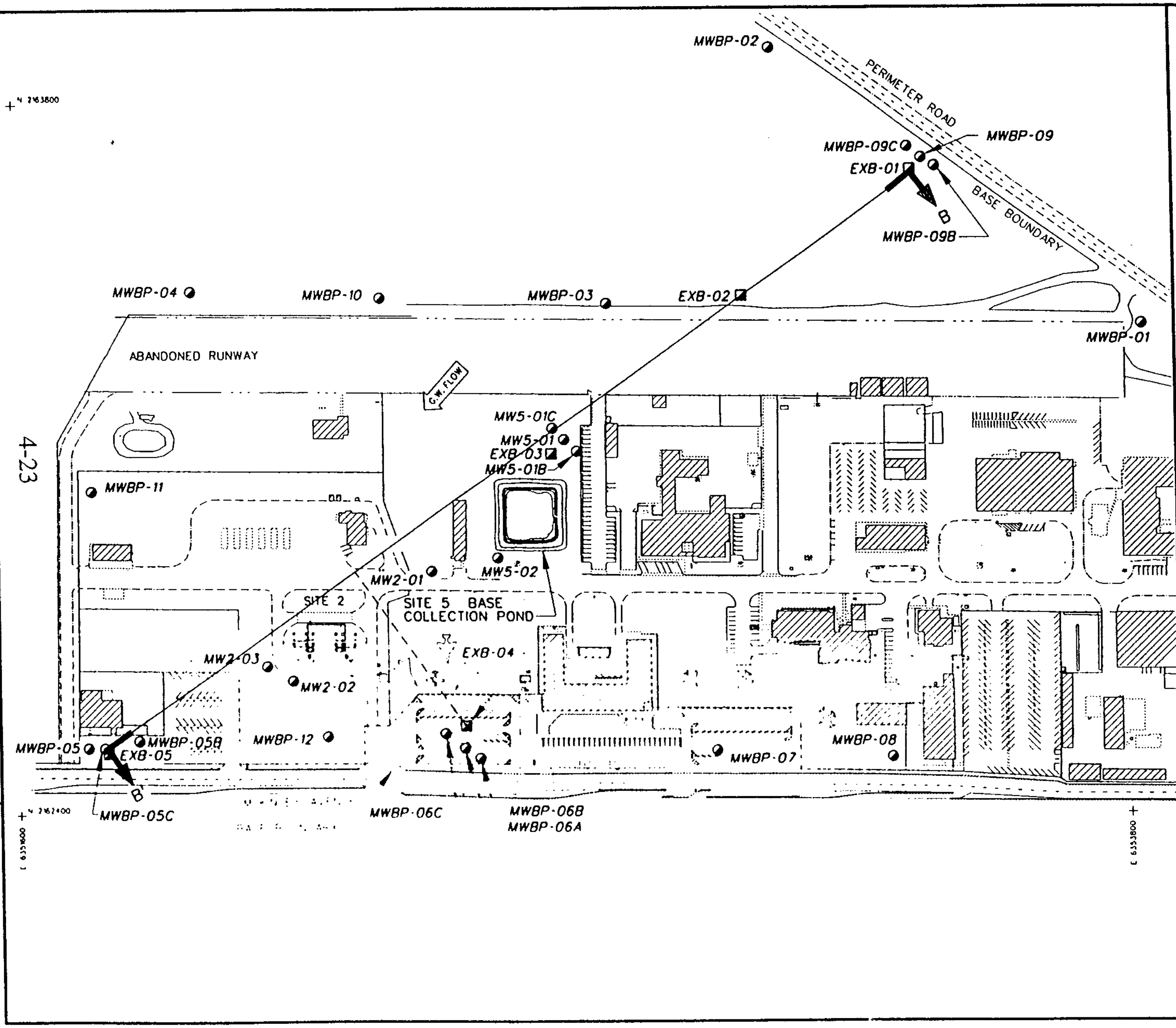
The field program simultaneously drilled exploratory borings, collected groundwater screening samples, and tested the rotary sonic methods with more traditional geophysical logging

Table 4-5

Summary of Initial Deep Aquifer Investigation Activities California Air National Guard - Fresno, California

Activity	Number of Borings/Wells	Number of Samples Analyzed	Analytical Parameters	Analytical Methods
Screening activities:				
Exploratory borings	5	--	--	--
Soil screening samples	--	27	VOC, Selected list[a]	Modified 601[b]
Groundwater screening samples	--	28	VOC, Selected list[a]	Modified 5030/601[b]
Confirmation activities:				
Intermediate monitoring wells[c]	4	8	VOC	8010/8020
Deep monitoring wells[d]	4	8	VOC	8010/8020

[a]Volatile organic compounds; refer to Appendix A for selected list of VOCs.
[b]Analyzed on field gas chromatograph.
[c]Intermediate wells: MWBP-09B, MW5-01B, MWBP-05B, MWBP-06B.
[d]Deep wells: MWBP-09C, MW5-01C, MWBP-05C, MWBP-06C.



LEGEND:

MWBP-03	EXISTING WATER TABLE MONITORING WELL
EXB-02	DEEP EXPLORATORY BORING
MW5-01B	MONITORING WELL INSTALLED TO APPROX. 115 FT. DEPTH
MW5-01C	MONITORING WELL INSTALLED TO APPROX. 147 FT. DEPTH
G.W. FLOW	GROUNDWATER FLOW DIRECTION
B B'	CROSS SECTION LOCATION

SCALE:
0 200 400 FEET

FIGURE 4-6
DEEP AQUIFER INVESTIGATION BORING AND MONITORING WELL LOCATIONS

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 9/30/94	DATE LAST REV.:	DRAFT. CHCK. BY: CTUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.016
DRAWN BY: G. PACHECO	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724.070.04.006

409724es.016 Oct 2, 1995 DJH

methods. Two exploratory soil borings, EXB-01 and EXB-02 were drilled and logged using both visual geologic and borehole geophysical methods. A comparison between the geologic and geophysical logging methods was made to determine the adequacy of the rotary sonic method. Comparisons between rotary sonic coring method and geophysical logging is provided in Section 4.5.1.5. The comparison established that the rotary sonic drilling could deliver the required stratigraphic information and the drilling program proceeded without further use of geophysical logging. The remaining three borings EXB-03 through EXB-05 were drilled and logged using visual geologic logging only.

4.5.1.1 Rotary Sonic Drilling Method

Borings were continuously cored with a 4.25-inch OD and 3.75-inch ID rotasonic core barrel. Core runs varied from 5 to 30 feet in length, with the core rod advanced first, followed by a six-inch OD steel outer casing. Over most of the drilled interval, the 6-inch casing was advanced to within 2 feet of the bit for each core interval to isolate intervals and prevent borehole collapse. The size differential between the outer casing (ID) and drill rod (OD) required the use of potable water to wash out the material from the annulus.

Core was retrieved by removing the entire length of drive casing and extruding the core from the drill rod into PVC troughs. The core was extruded using the vibrating action of the rig and with water pressure when required. Geologic core logging was accomplished using the Unified Soil Classification System (USCS) (USBR 5006-86). Geologic logging was complicated by two factors unique to the rotary sonic method: core growth and rind formation.

Core growth results in the retrieval of a core length longer than the drilled interval. Core expansion was often observed, with a 10-foot core run potentially returning up to 20 feet of core. This was due to a number of factors. First, the physical process of extruding the core from the rod using vibration could cause core growth (extrusion stretch). The observation of the physical character of the core showed indications of stretch. Second, the difference in the ID and OD of the core barrel (0.5 inches) and the larger diameter of the drill bit shoe caused core growth. If the formation being penetrated was loose, the extra material could be pushed into the walls of the borehole. Core growth would be minimal in this case. If the formation was dense and compacted, the material would tend to take the path of least resistance into the core rod, thus causing core growth.

The core was laid in troughs and contact depths were determined by interpolating the percentage core growth over the drilled interval. The recovered core was measured with a

steel rule and a simple ratio of recovered versus drilled interval was determined. Contacts were adjusted accordingly; for example, if observed core expansion was 50 percent, then a 2-foot-thick sand core would be logged as 1.5 feet in the logs. Likewise, a 5-foot-thick silt core would be assigned a relative thickness of 3.5 to 4 feet. Where growth was clearly the result of stretch over specific interval, a greater percentage of the correction was applied to that interval. Boring logs show the corrected depths.

Errors in contact depth are limited to the length of the core run and errors are not cumulative; i.e., errors in contact depths do not carry over into the next run. Core runs above and below this run would be unaffected by the core growth observed in a given interval, because their respective starting and ending depths were fixed. The continuous core provided by the sonic drilling method allowed for detailed descriptions of subsurface lithology.

The vibratory action of the rotary sonic drilling method appeared to cause finer-grained material to migrate towards the outside of the core, thus producing a rind. This rind can mask the type of sediments, particularly when small amounts of coarse-grained material are present. However, the rind interference is easily overcome by examining the interior of the core.

4.5.1.2 Deep Aquifer Groundwater Screening Samples

Several groundwater screening samples were collected from each exploratory boring to determine the vertical extent and magnitude of groundwater contamination across the area of interest. The information provided by groundwater screening samples assisted in determining zones of concern beneath the water table and in designing the deep monitoring well network.

As the core from the exploratory boring was retrieved and logged, a decision was made as to whether to collect a groundwater screening sample. The focus of the screening samples was to identify the zones with the highest migration potential for contaminants. If the core showed a predominantly sandy material with a good degree of moisture content, then a groundwater screening sample was attempted. When the core indicated a finer-grained sediment, groundwater screening samples were generally not attempted unless the material appeared to be saturated.

Groundwater screening samples were collected during the drilling of the exploratory soil borings using the previously defined rationale. When a screening sample was justified, the drill bit was removed from the end of the core barrel (drill rod) and the sampling device was

attached to the end of the drill rod. The sampling device used was a Hydropunch II sampler. It was lowered into the borehole and was either pushed or vibrated 1.5 to 3 feet into undisturbed material. The sampler had a sacrificial tip that allowed the sleeve to be retracted, exposing a Teflon screen. A small diameter Teflon bailer was used to collect the groundwater screening sample. The seal between the drill rod and sampler was water-tight. If the formation being sampled did not produce water, a sample could not be collected. At times, the hydropunch was allowed to stay open for a period from 15 to 60 minutes before enough water was available to collect a screening sample. The majority of the time, however, the sample could be collected immediately. Once collected, the sample was transferred to the field laboratory for GC analysis (Section 4.5.1.3). A total of 28 groundwater screening samples were collected and analyzed for VOCs from the five exploratory borings. Results of these analyses are discussed in Section 4.5.2.

4.5.1.3 Deep Aquifer Soil Screening Samples

Soil samples from the exploratory borings were also collected from the extracted soil core. In accordance with this addendum, soil samples for screening analysis were collected from finer-grained material. Samples were collected at a minimum frequency of one per 50 feet. Fine-grained material from the soil core was placed into 60-milliliter (mL) glass jars and were transferred to the field laboratory for VOC analysis.

The results of the soil analysis was used to determine the handling, storage, and disposal of the waste soil. The disposal option rationale is specified in the SAP addendum (IT, 1993a). A total of 27 soil samples were analyzed for chlorinated VOCs during the exploratory boring program. The results of these analysis are discussed in Sections 4.7 and 6.2.1.3.

4.5.1.4 Deep Aquifer Field GC Analysis

A GC in a field laboratory setting was used to meet two objectives:

- Provide screening data on groundwater samples collected from the exploratory borings to track VOC contaminant presence and absence.
- Provide screening data on soil screening samples collected from the soil core for VOC analysis to determine the disposition of IDW.

The GC was used to provide screening analysis on a real-time basis in order to assist in guiding the deep aquifer investigation. Results of groundwater screening samples were plotted on a sketch map in the field to observe contaminant trends. Additionally, soil

screening data from the GC was used as a decision-making tool on the disposition of soil cuttings from the exploratory borings and subsequent monitoring well boreholes. The criteria for determining the disposition of IDW are outlined in the initial deep aquifer investigation addendum to the SAP (IT, 1993a).

Field laboratory equipment, calibration, analysis procedures and materials used are summarized in Appendix A.

4.5.1.5 Downhole Geophysical Logging

Downhole geophysical logging was conducted in two exploratory borings (EXB-01 and EXB-02) to determine the adequacy of the rotasonic drilling for stratigraphic drilling. Natural gamma and induction logs were run from ground surface to total depth. Once these two holes were advanced to 250-foot depth, a 3-inch-diameter Schedule 80 PVC pipe was inserted into the 6-inch-diameter borehole before the outer steel casing was removed. The geophysical suite was then run within the PVC casing. Geophysical logs used were induction (resistivity) and natural gamma (gamma ray). The borehole annulus was water-filled below the water table and air-filled above. Induction logs were run with a 1.25-inch-diameter DHT-1 induction tool with a detector spacing of 24 inches. The induction tool data was recorded as both conductivity and its reciprocal resistivity. The gamma ray log was run using a 1.7-inch-diameter natural gamma tool with a 4-inch detector length at a logging speed of 24 feet per minute.

Geophysical logs are standard methods for lithology determination in petroleum and mining applications. Although application of geophysical logging in environmental application has a shorter history, recent experience has proven it to be a reliable lithologic indicator. Borings EXB-01 and EXB-02 allowed for a comparison of the rotary sonic drilling method against geophysical methods, assuming that geophysics provided the best overall picture of the lithologic section. A detailed comparison of the geophysical logs and visual geologic logging is presented in Appendix D. Comparisons of rotasonic core to geophysical logs indicated that rotasonic coring was acceptable for geologic characterization of the site and the drilling program continued without the aid of borehole geophysics.

4.5.1.6 Deep Aquifer Geotechnical Samples

To determine physical properties of sediments below the water table, geotechnical samples were collected from the extracted soil core. Samples were collected from both fine- and coarse-grained material. Fine-grained samples were taken from selected lengths of core that

were intact and appeared to be relatively undisturbed. They were placed in PVC liners that were capped, and were submitted to the geotechnical laboratory for analysis. The coarse-grained material was considered to be disturbed as it came out of the core barrel; therefore, analyses that apply generally to undisturbed samples were not performed. In addition, sufficient volume was also collected in order to analyze each sample for total organic carbon content. Organic carbon content can be useful in assessing chemical partioning coefficients for contaminant migration evaluations.

A total of ten fine-grained and eight coarse-grained geotechnical samples were collected from the exploratory borings. Table 4-3 lists the samples collected and their respective analytical parameters.

4.5.2 Screening Data Analysis for Deep Well Network Design

Geologic and chemical data were used to design the deep monitoring well network. No discussion of the monitoring well installation objectives can be held without evaluating this data. Monitoring wells were to be installed in the zone of highest groundwater contamination and in a water-producing zone below any detected contamination. Therefore, the first objective of the review was to determine where COCs were present so that the two monitoring zones could be identified. The second objective of screening data analysis was to evaluate the geophysical logs and visual geologic logs to determine the reliability of the geologic information. This would provide greater confidence in designing the depths of the deep wells in their stratigraphic correlation.

A meeting between DTSC, HAZWRAP, and IT personnel was held at the Base to develop a consensus on the design of the deep monitoring well network. The following paragraphs summarize the conclusions of that meeting.

Table 4-6 lists the groundwater screening samples collected, their elevations, soil types, and field screening results. This data and the water table monitoring well chemical data was available to determine well screen depths. PCE was detected in 3 of 28 Hydropunch samples, all of which were collected at or downgradient from Site 5-BCP; PCE was not detected upgradient of Site 5-BCP. PCE was detected only at fairly shallow depths (108 feet), and was not observed at or below a depth of 133 feet. Because PCE was only detected at and downgradient from Site 5-BCP, and because the depths of detection suggested a nearby source area, PCE was considered to be a COC to be targeted in the monitoring well installations.

Table 4-6

Deep Aquifer Investigation
Hydropunch Groundwater Screening Sample Results
California Air National Guard - Fresno, California

(Page 1 of 2)

Exploratory Boring ID	Hydropunch Sample Depth (ft)	Hydropunch Sample Elevation (ft msl)[a]	Date Collected	Soil Type	Field GC[b] Screening Results (μg/L)[c]			
					Total DCE[d]	1,1-DCA[e]	TCE[f]	PCE[g]
EXB-01	122	202.7	10-06-93	sandy silt/ silty sand	ND[h]	ND	ND	ND
	142	182.7	10-06-93	silty sand	ND	ND	ND	ND
	215	109.7	10-07-93	silty sand	ND	ND	ND	ND
	248	76.7	10-07-93	sand	ND	ND	ND	ND
EXB-02	101	223.2	10-12-93	silty sand	**30**	ND	**200**	ND
	133	191.2	10-12-93	sand	**30**	ND	**150**	ND
	154	170.2	10-12-93	sand/sandy silt	ND	ND	**30**	ND
	220	104.2	10-13-93	silt with sand	ND	ND	ND	ND
	248	76.2	10-14-93	silty sand	ND	ND	ND	ND
EXB-03	88	235.6	10-15-93	sand	**10**	ND	**9**	**26**
	101	222.6	10-15-93	silt	ND	ND	**25**	**10**
	134	189.6	10-15-93	clayey silt	**41**	**6**	**320**	ND
	152	171.6	10-16-93	sand	ND	ND	**11**	ND
	171	152.6	10-16-93	sand	ND	ND	**120**	ND
	207	116.6	10-16-93	sandy silt	ND	ND	ND	ND
	247	76.6	10-17-93	sandy silt	ND	ND	**16**	ND
EXB-04	106	215.1	10-27-93	sandy silt	ND	ND	ND	ND
	142	179.1	10-27-93	sand	**39**	ND	**440**	ND
	162	159.1	10-27-93	sandy silt	ND	ND	ND	ND
	186	135.1	10-27-93	silty sand	ND	ND	ND	ND
	208	115.1	10-28-93	silty sand	ND	ND	ND	ND

Table 4-6

Deep Aquifer Investigation
Hydropunch Groundwater Screening Sample Results
California Air National Guard - Fresno, California

Exploratory Boring ID	Hydropunch Sample Depth (ft)	Hydropunch Sample Elevation (ft msl)[a]	Date Collected	Soil Type	Field GC[b] Screening Results (μg/L)[c]			
					Total DCE[d]	1,1-DCA[e]	TCE[f]	PCE[g]
EXB-05	108	212.3	10-19-93	sandy silt	ND	ND	**290**	**106**
	143	177.3	10-20-93	silty sand	ND	ND	**54**	ND
	162	158.3	10-20-93	sand with silt	ND	ND	**29**	ND
	171	149.3	10-20-93	silty sand/ sand	ND	ND	**59**	ND
	202	118.3	10-20-93	silt	ND	ND	ND	ND
	223	97.3	10-21-93	silt	**10**	ND	**180**	ND
	251	69.3	10-21-93	sand	ND	ND	**14**	ND

[a]Feet mean sea level.
[b]GC - gas chromatograph.
[c]μg/L - Micrograms per liter, or parts per billion. Quantitation limit for all compounds = 5 μg/L.
[d]Total of 1,1-dichloroethene, trans-, and cis-1,2-dichloroethene.
[e]1,1-Dichloroethane.
[f]Trichloroethene.
[g]Tetrachloroethene.
[h]ND - Not detected.

It is apparent from Table 4-6 that TCE was detected at depth upgradient of Site 5-BCP in EXB-02. TCE is also present at concentrations exceeding 400 parts per billion (ppb) in water table monitoring well MWBP-09, which is located on the upgradient Base boundary (Figure 4-6). TCE is detected at greater depths, and at higher concentrations downgradient, towards EXB-05. TCE was detected at relatively low concentrations near the water table at Site 5-BCP, and concentrations increased with depth at this location. If TCE had been introduced through the BCP, near-surface concentrations would be expected to be similar to or higher than levels detected with depth. Available data did not indicate that TCE was never disposed of at Site 5-BCP, but in comparison to concentrations observed upgradient, TCE releases, if any, were insignificant. Therefore, TCE was not considered to be a COC, and would not influence the depths of deeper monitoring wells to be installed. Additionally, it was known that more regional investigations to be conducted by another contractor for the city of Fresno would be focusing on TCE groundwater contamination. Because TCE did not appear to be primarily related to the Base, it was decided to not duplicate investigation efforts such that PCE would be the COC for the Base deep well network.

Dichloroethene (DCE) and 1,1-dichloroethane (DCA) were only sporadically detected in groundwater screening samples, and were only detected when TCE was present. These two organics were not detected when PCE was present.

The depths of the wells were, therefore, set to monitor the zone of highest PCE contamination beneath the water table, and a water-producing zone below any detected PCE contamination.

The next step in the monitoring well design was to assess the geology to screen coarser-grained layers preferentially carrying contaminants in groundwater. A preliminary sketch cross section of the geologic interpretation was produced to assist in the design. Both visual logs and geophysical logs (where available) were used to construct the sketched section.

A field analysis of the geophysical logs from EXB-01 and EXB-02 was also completed prior to designing the deep well network. This was accomplished to determine the reliability and consistency of the visual logs afforded by the sonic drilling method versus logs associated with the geophysics. It was determined that both logging procedures had strengths and weaknesses.

In summary, the soil core provided by the rotary sonic drilling consistently recovered all of the material drilled. This allowed for a detailed geologic log to be produced. However, the method did experience core growth, where the amount of material retrieved was greater than the interval drilled. Some correcting factors were used to better estimate contact depths.

Geophysical techniques also had complications due to the type of sediments being logged. Natural gamma measures the natural radioactivity of a given soil. Clays are nearly always associated with higher radioactivities, owing to their content of potassium. However, some sands present in the area were derived from Sierra Nevada source rock having a high potassium content thus causing the sands to have a higher radioactivity than normal. Because of this, the natural gamma log sometimes showed a clay-like response where the visual log showed a sand layer, thereby complicating the interpretation of certain portions of the gamma log. The presence of a sand was verified by the response of the resistivity log.

Overall, the visual logs produced from the sonic cores were considered acceptable for the purposes of the investigation. Some contact depths showed a discrepancy of 0.5 to 2 feet between the visual and geophysical logs. However, neither method was deemed to provide better information than the other. They were seen more as complimentary logs, each providing commentary on the other. As such, visual logs were acceptable to use in the explanation of the hydrogeology and in designing the monitoring well network. A more detailed discussion of the comparison of the two methods, along with an explanation of advantages and disadvantages of the sonic coring method, is provided in a technical paper published based on the results of this field event. The paper is included as Appendix D.

The zone of highest PCE contamination was directly beneath the water table monitoring wells. Hydropunch samples were generally collected 10 to 15 feet below the depth of the existing wells, near to the depth of a continuous, thin silty sand layer. No clean sand units were present in this depth range and the wells were expected to have low production. Initial review of exploratory boring logs showed a possible presence of a thin retarding layer between the existing wells and the thin silty sand layer. The wells were, therefore, placed at a depth that would screen below this potential aquitard. These wells were labeled as "B" series wells. Upon a later, more detailed review, no true, competent retarding layer was identified immediately beneath the water table.

The next zone to be monitored was a continuous, relatively thick layer of clean to silty sands, present between 121 to 135 feet bgs (194 to 180 feet mean sea level [msl]) at EXB-01 to 141

to 148 feet bgs (172 to 179 feet msl) at EXB-05. No PCE had been detected within, or below, this sand layer. Each of the deeper monitoring wells, designated as the "C" series wells, were targeted to intercept this sandy layer. A detailed cross section of the hydrogeologic regime is presented in Figure 4-7.

4.5.3 Deep Monitoring Well Installation

Once the targeted monitoring well depths had been agreed upon and established by DTSC and HAZWRAP, wells were installed using air rotary/casing hammer drilling techniques, according to the procedures and construction practices specified in the SAP addendum (IT, 1993a). A total of eight wells were installed at four different locations across the western portion of the Base. Two were installed at each location, one being the "B" series and one the "C" series well. Each well was installed in a separate borehole. The term "well cluster" is used only to denote wells located near to each other, not wells installed in the same borehole. Deep wells installed with the "B" or "C" suffix are shown in Figure 4-6.

The four "B" wells were installed from total depth ranges of 114 to 118 feet bgs. The four "C" wells were installed from total depth ranges of 146 to 149 feet bgs. As drilling advanced, 10-inch-diameter steel casing was driven behind the bit to seal off any upper zones of contamination. Once at the desired depth, well materials were installed through this outer casing. Wells were constructed with 5-inch-diameter, Schedule 80 PVC screen, and casing. Screen lengths were 10 feet and slot sizes were 0.010 inch. The 10-inch casing was removed from the borehole as the well was constructed and grouted in place. Following installation, the wells were developed, completed, and surveyed in accordance with the work plan addendum. Wells associated with the deep aquifer investigation were drilled, installed, and developed in November 1993.

Each deep monitoring well was developed by surging, swabbing, and pumping. Once pumping began, the pumping rate was increased in a stepwise fashion. Maximum pumping rates for most of the wells reached approximately 9 gallons per minute (gpm) with acceptable drawdowns, even in the wells not expected to yield much water. Field readings of pH, temperature, turbidity, and conductivity were collected throughout the development process. Final turbidities for five of the eight wells were below 5 nephelometric turbidity units (NTU), and all of the wells had final readings below 20 NTU.

Deep monitoring well specifications are provided in Appendix B. Figure 4-7 shows the well screen intervals for each well cluster on Base in cross-sectional view. This shows the relative

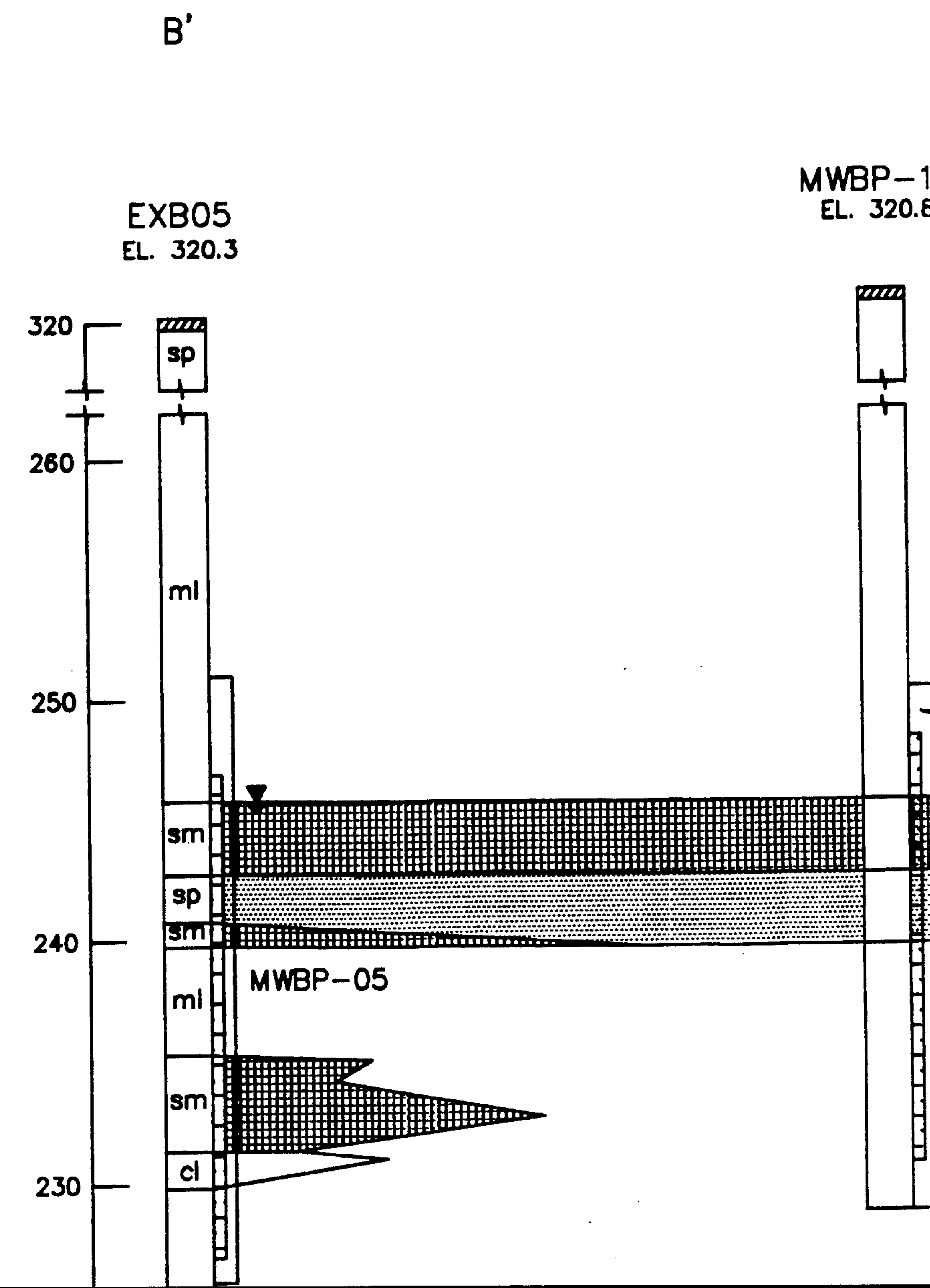
1

DRAWING NO.: 409724-D-138

PROJECT NO.: 409724

INITIATOR: S. LOGAN

PROJECT MGR.: D. BURTON



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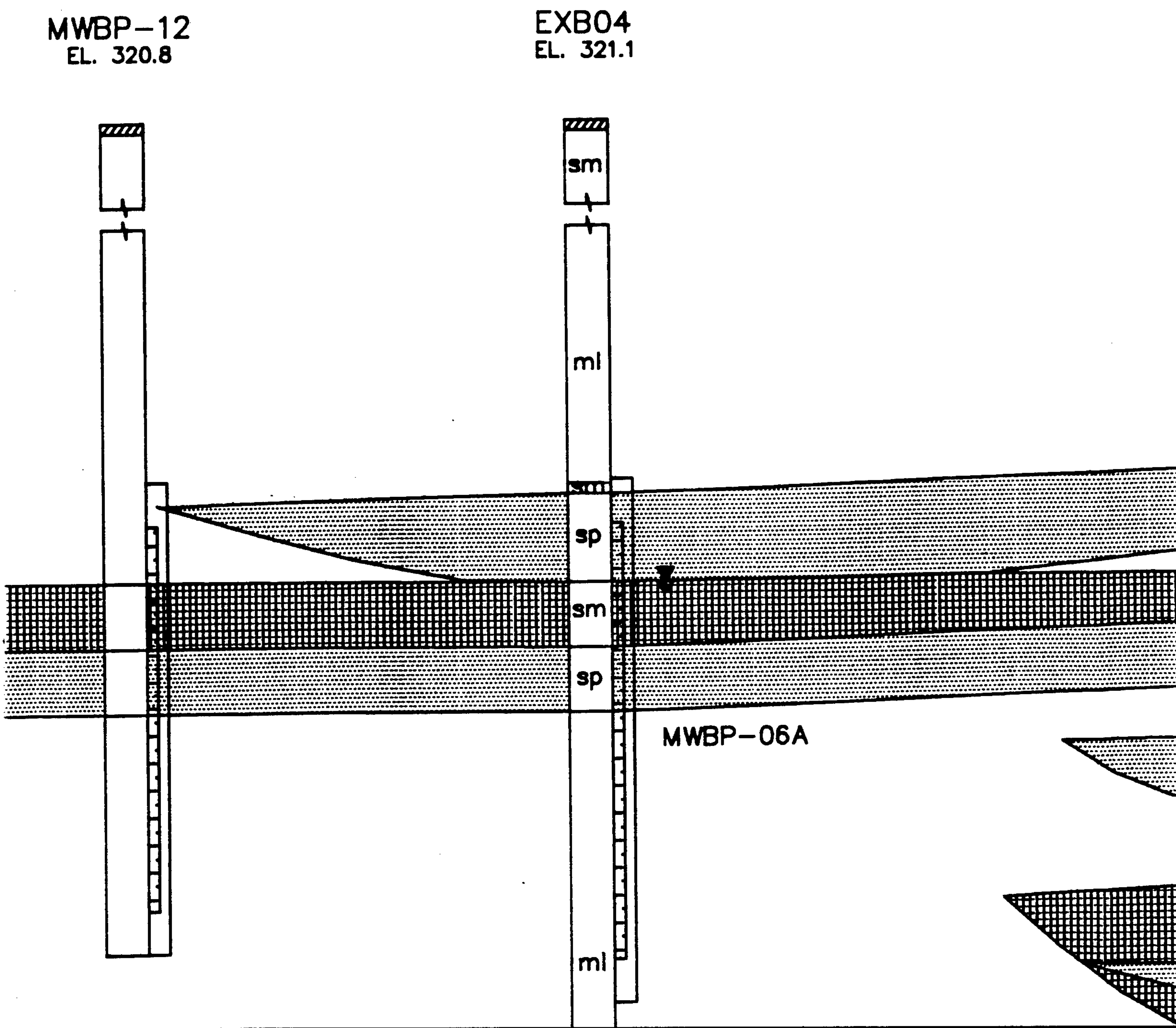

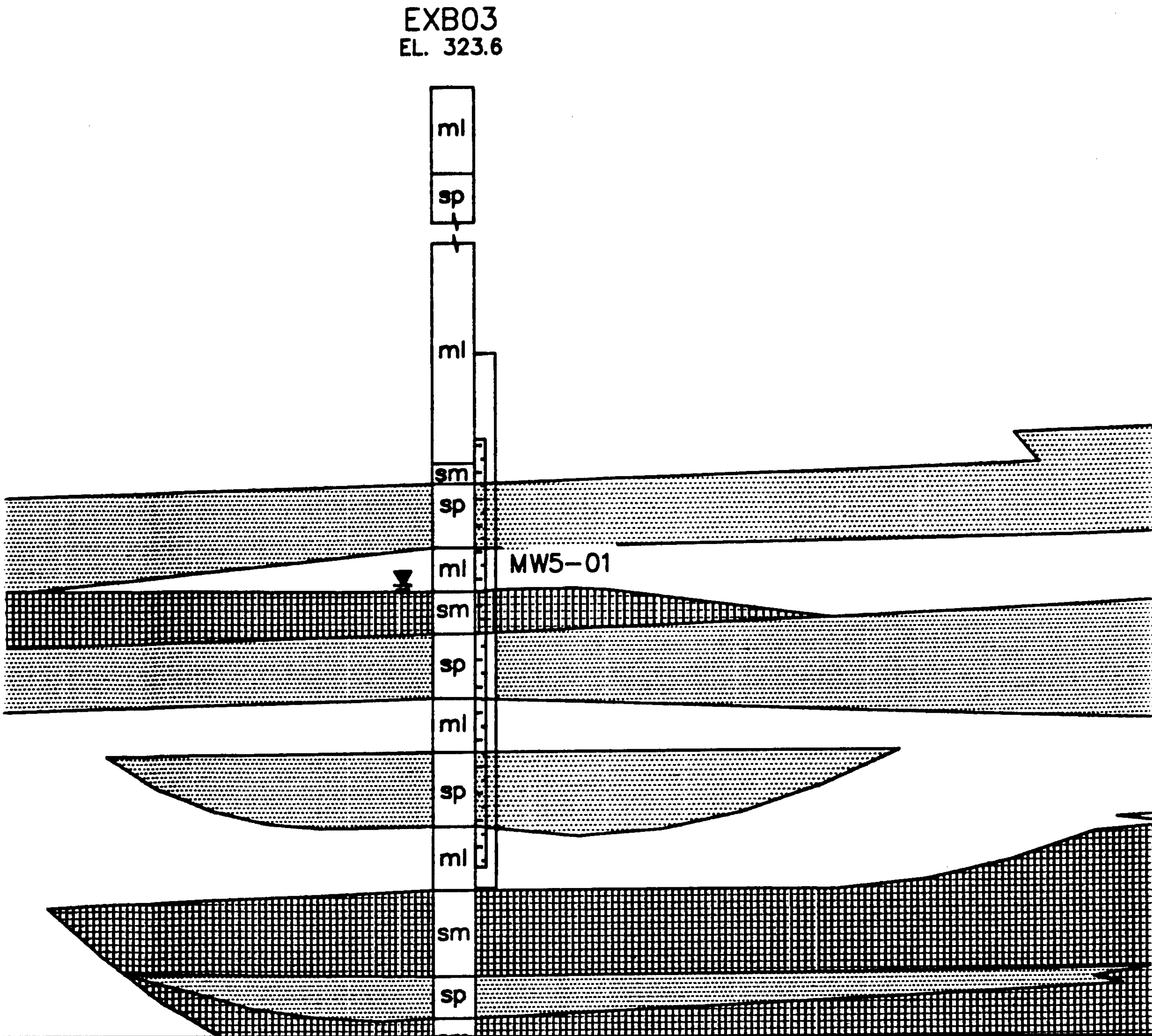
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ml
sp
ml
sm
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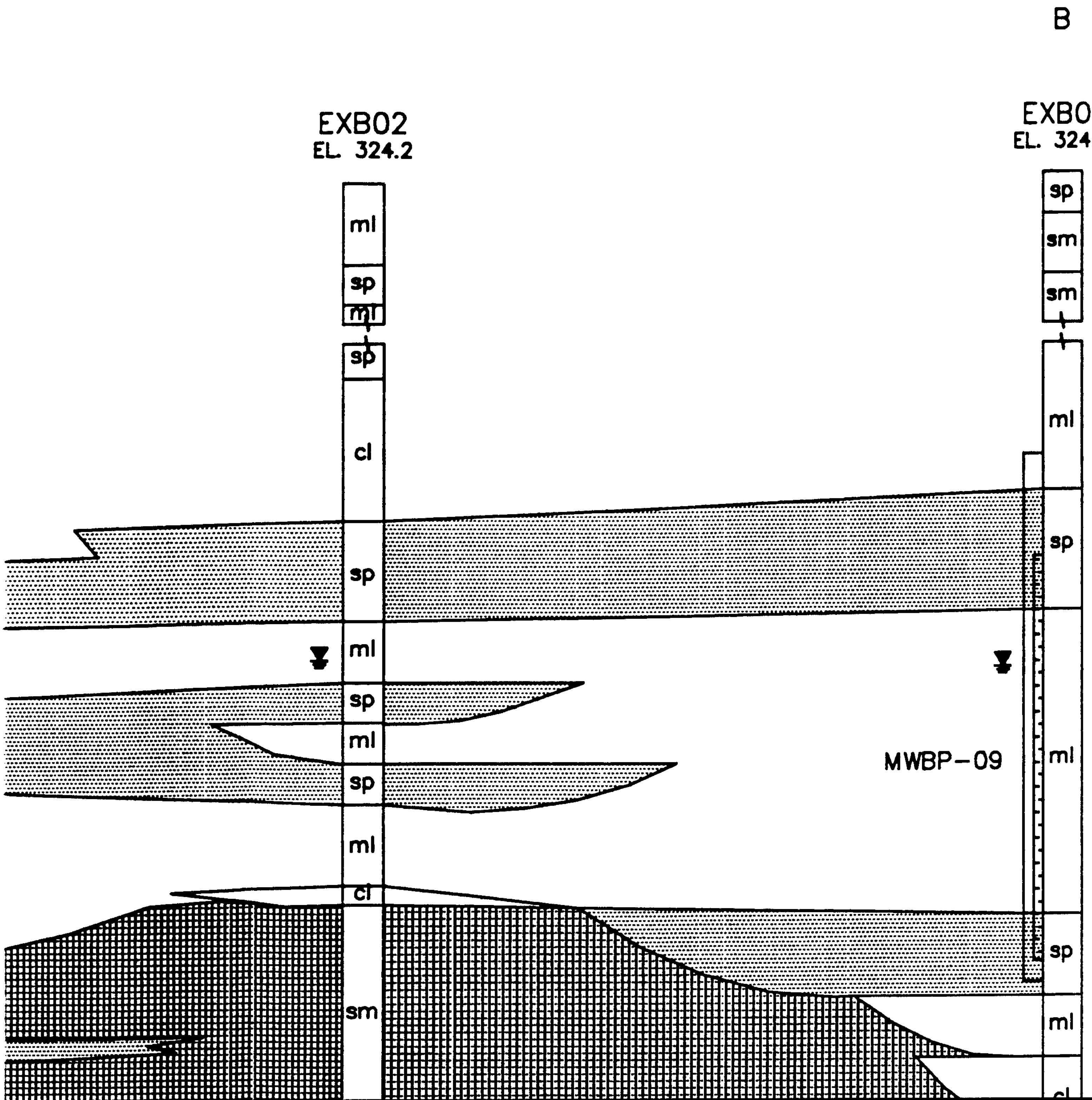
ml
MW5-01
sm
sp
ml
sp
ml
sm
sp


B
EXB02
EL. 324.2
EXB0
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ml
sp
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MWBP-09
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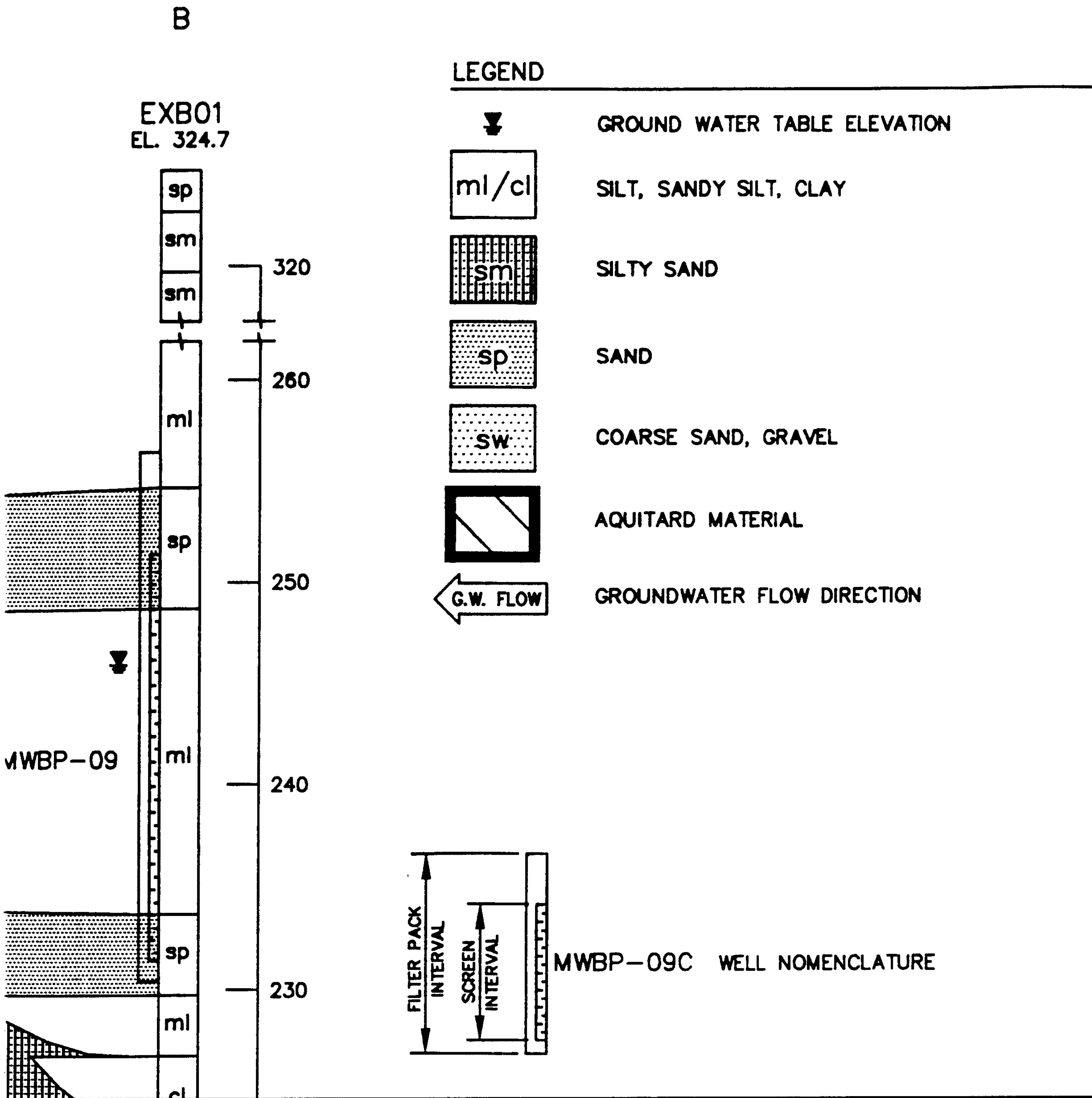
cl


B
EXB01
EL. 324.7
sp
sm
sm
ml
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ml
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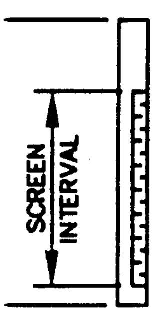
ml
cl
320
260
250
240
230
MWBP-09
LEGEND
GROUND WATER TABLE ELEVATION
ml/cl
SILT, SANDY SILT, CLAY
sm
SILTY SAND
sp
SAND
sw
COARSE SAND, GRAVEL
AQUITARD MATERIAL
G.W. FLOW
GROUNDWATER FLOW DIRECTION
FILTER PACK INTERVAL
SCREEN INTERVAL
MWBP-09C
WELL NOMENCLATURE

LEGEND

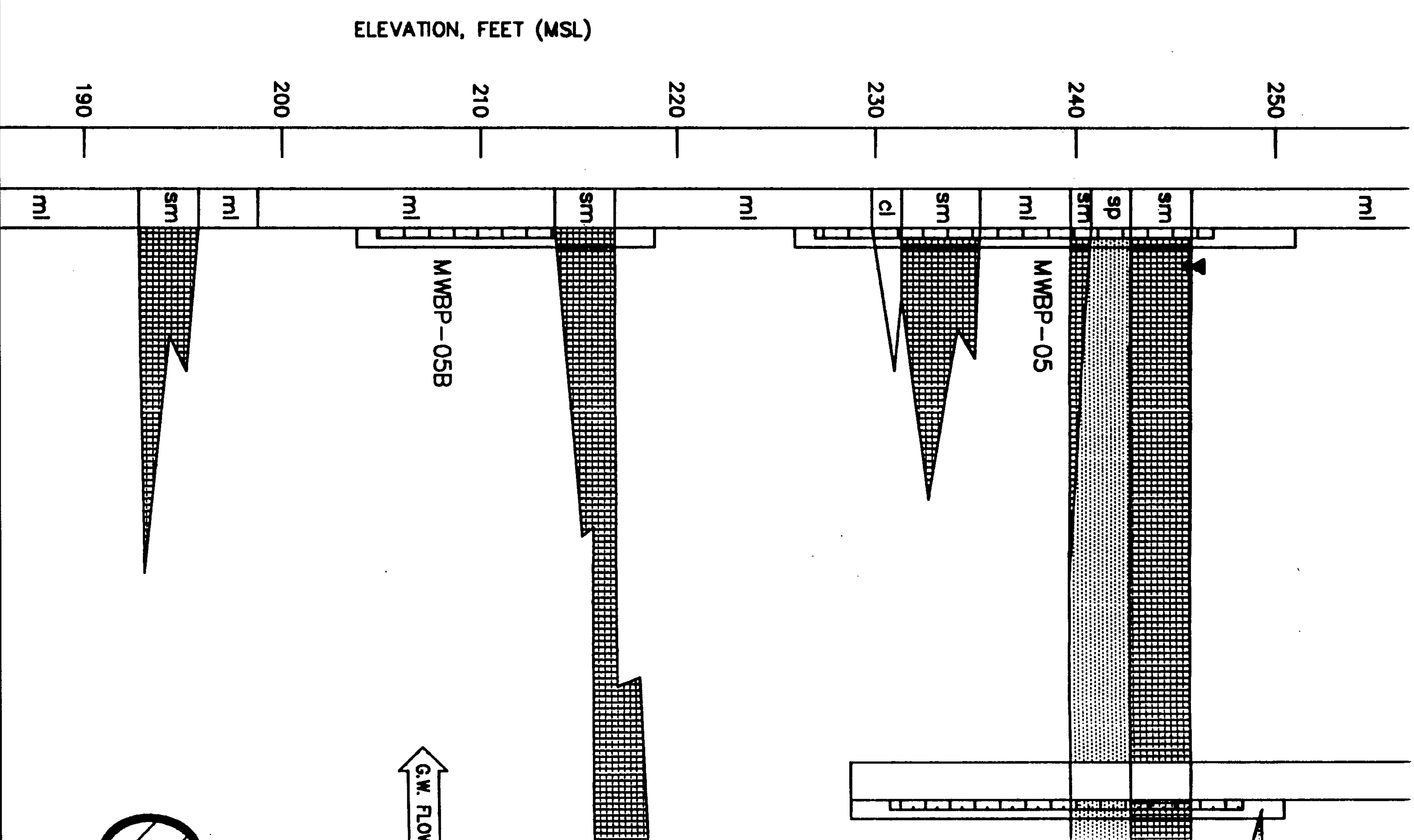
▼	GROUND WATER TABLE ELEVATION
ml/cl	SILT, SANDY SILT, CLAY
sm	SILTY SAND
sp	SAND
sw	COARSE SAND, GRAVEL
	AQUITARD MATERIAL
G.W. FLOW	GROUNDWATER FLOW DIRECTION

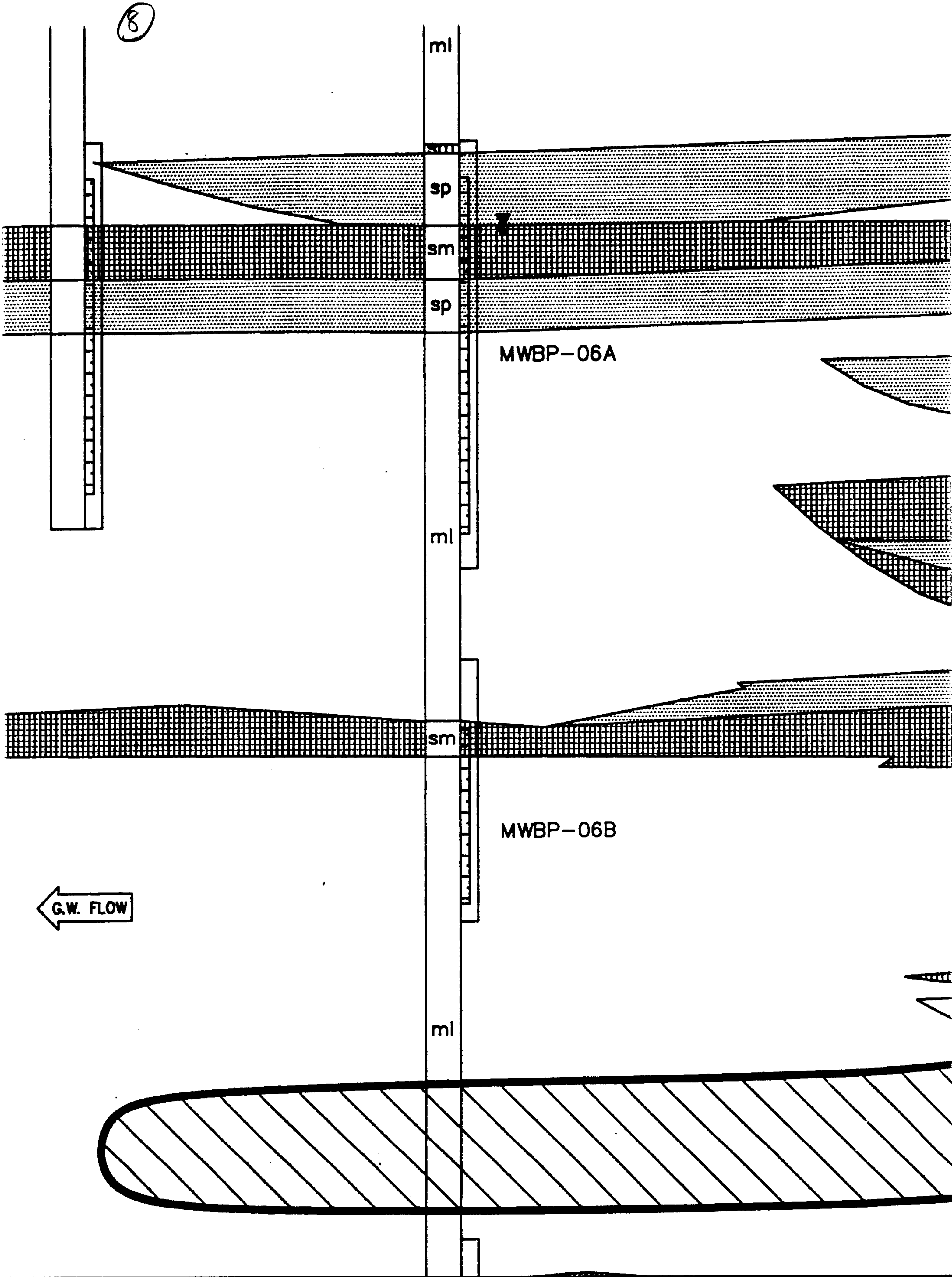


MWBP-09C WELL NOMENCLATURE

(7)

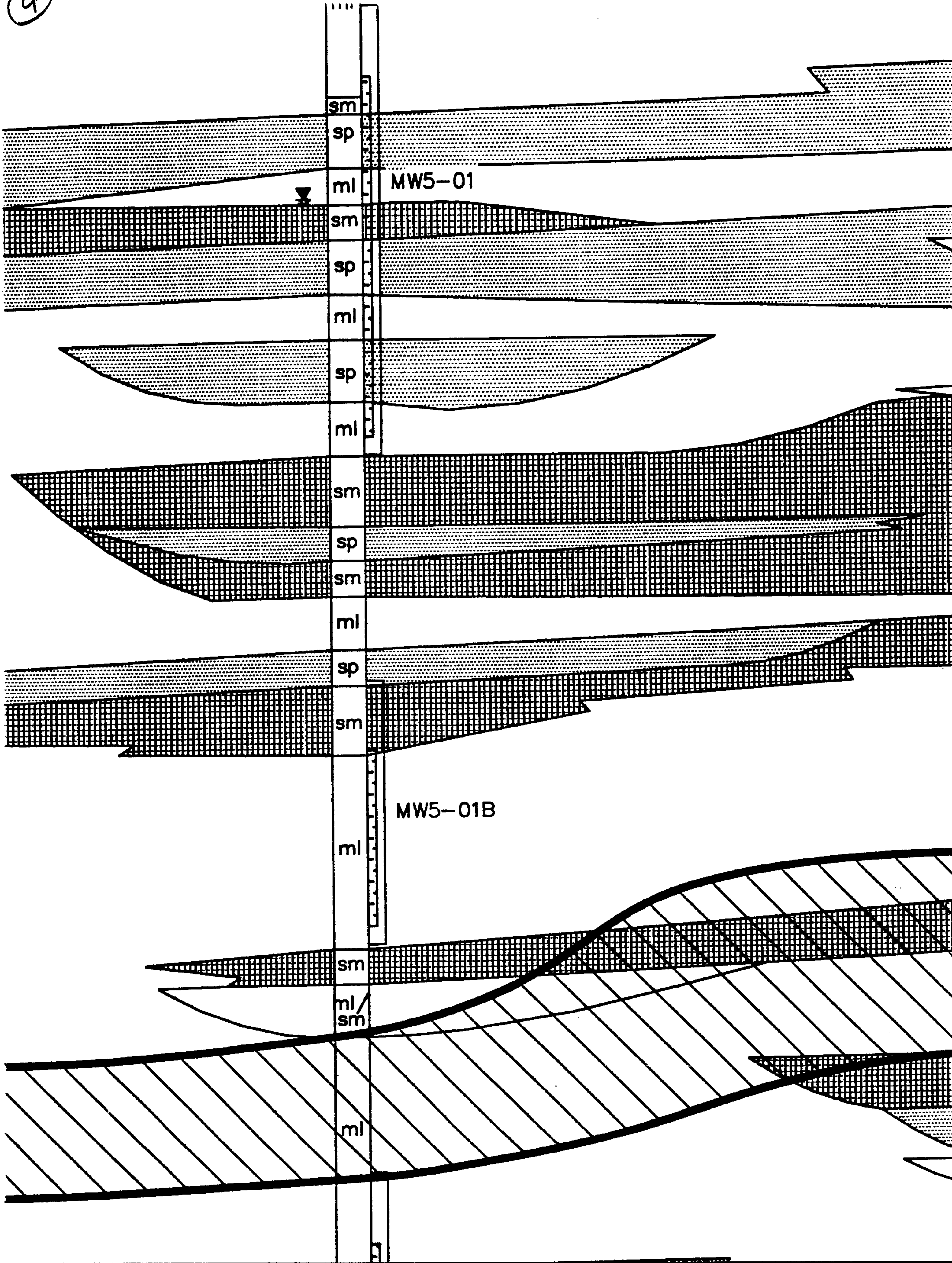
5	DATE LAST REV.:	INITIATOR: S. LOGAN
	DRAWN BY:	PROJECT MGR.: D. BURTON





8
ml
sp
sm
sp
MWBP-06A
ml
sm
MWBP-06B
G.W. FLOW
ml

9



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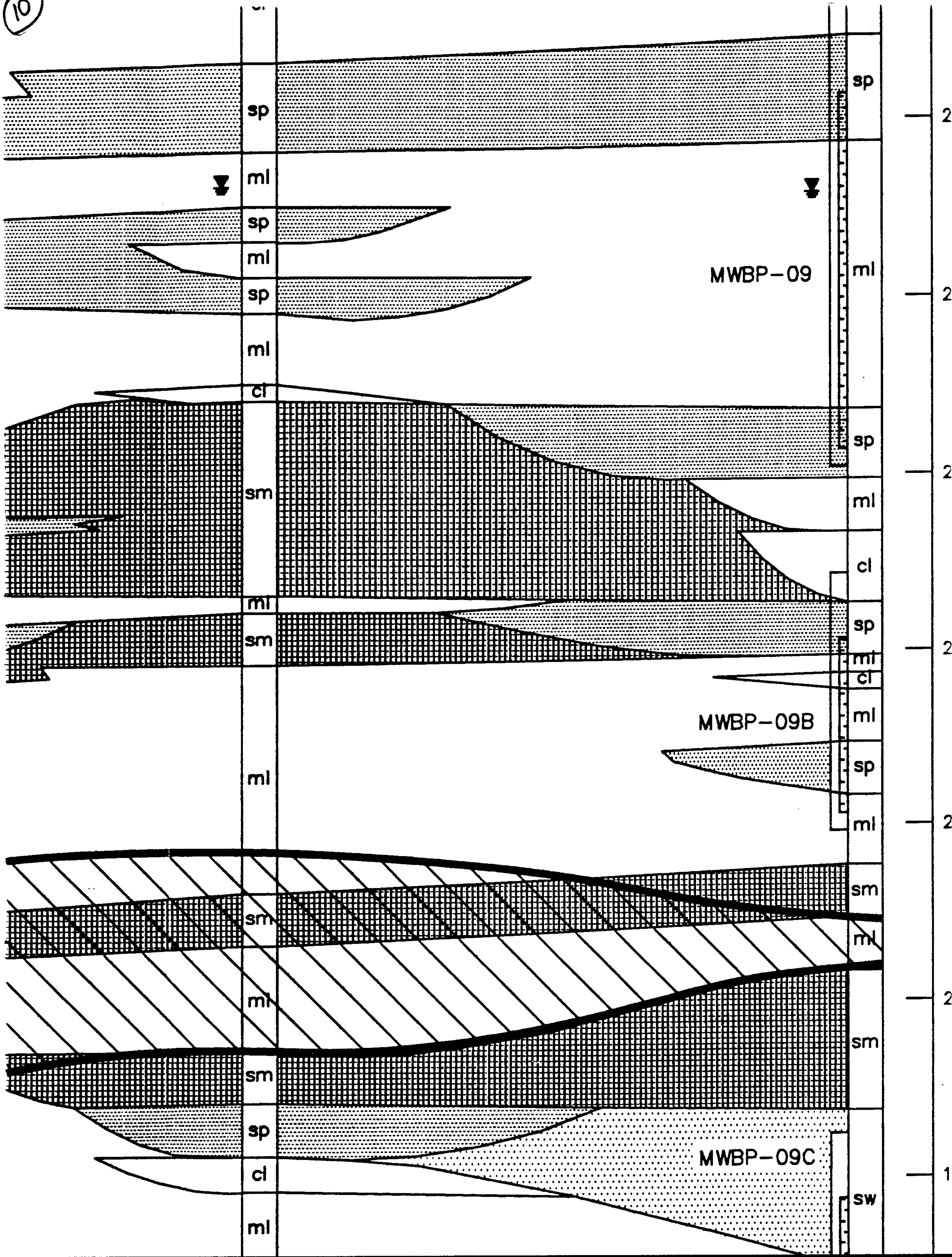
MWBP-09
MWBP-09B
MWBP-09C
sp
ml
sp
ml
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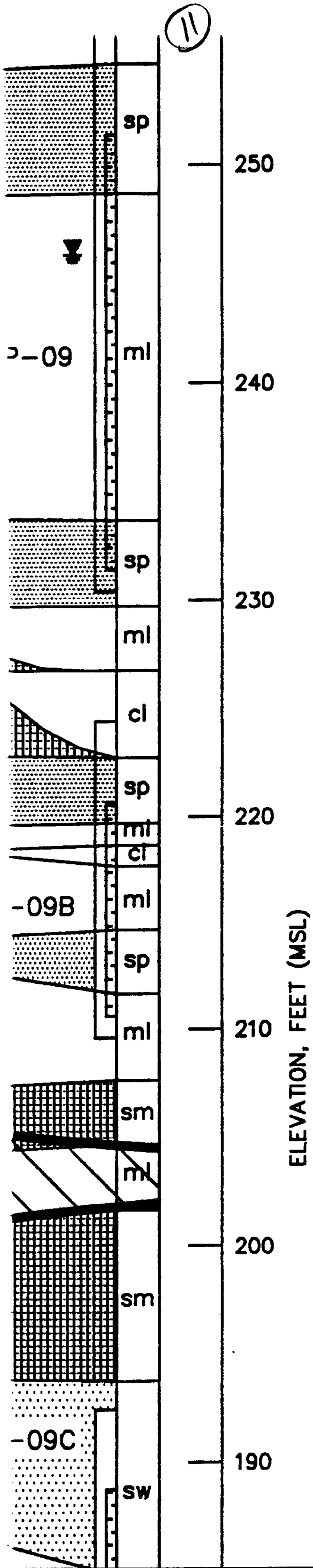
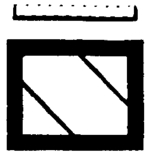
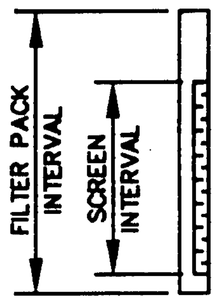




AQUITARD MATERIAL

GROUNDWATER FLOW DIRECTION



MWBP-09C WELL NOMENCLATURE

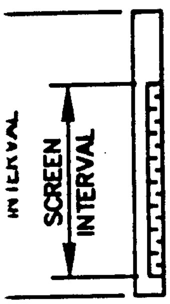
NOTE: REFER TO SECTION 5.3 IN TEXT FOR HYDROGEOLOGIC INTERPRETATION

HORIZONTAL SCALE

12

AQUITARD MATERIAL

G.W. FLOW GROUNDWATER FLOW DIRECTION



MWBP-09C WELL NOMENCLATURE

NOTE: REFER TO SECTION 5.3 IN TEXT FOR HYDROGEOLOGIC INTERPRETATION

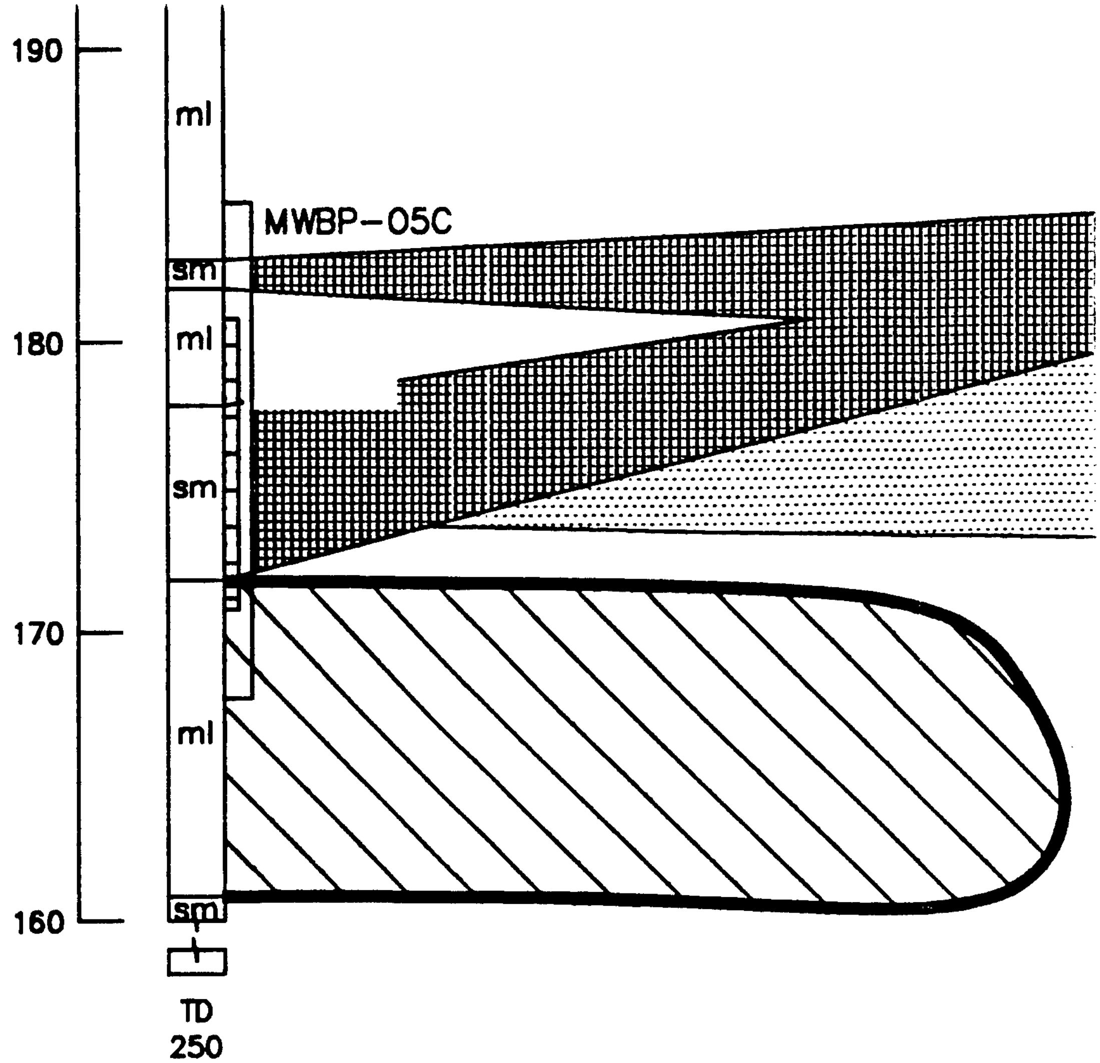
HORIZONTAL SCALE

0 80 160 240 FEET

13

STARTING DATE: 2/28/95

DRAWN BY: D. HIGGS



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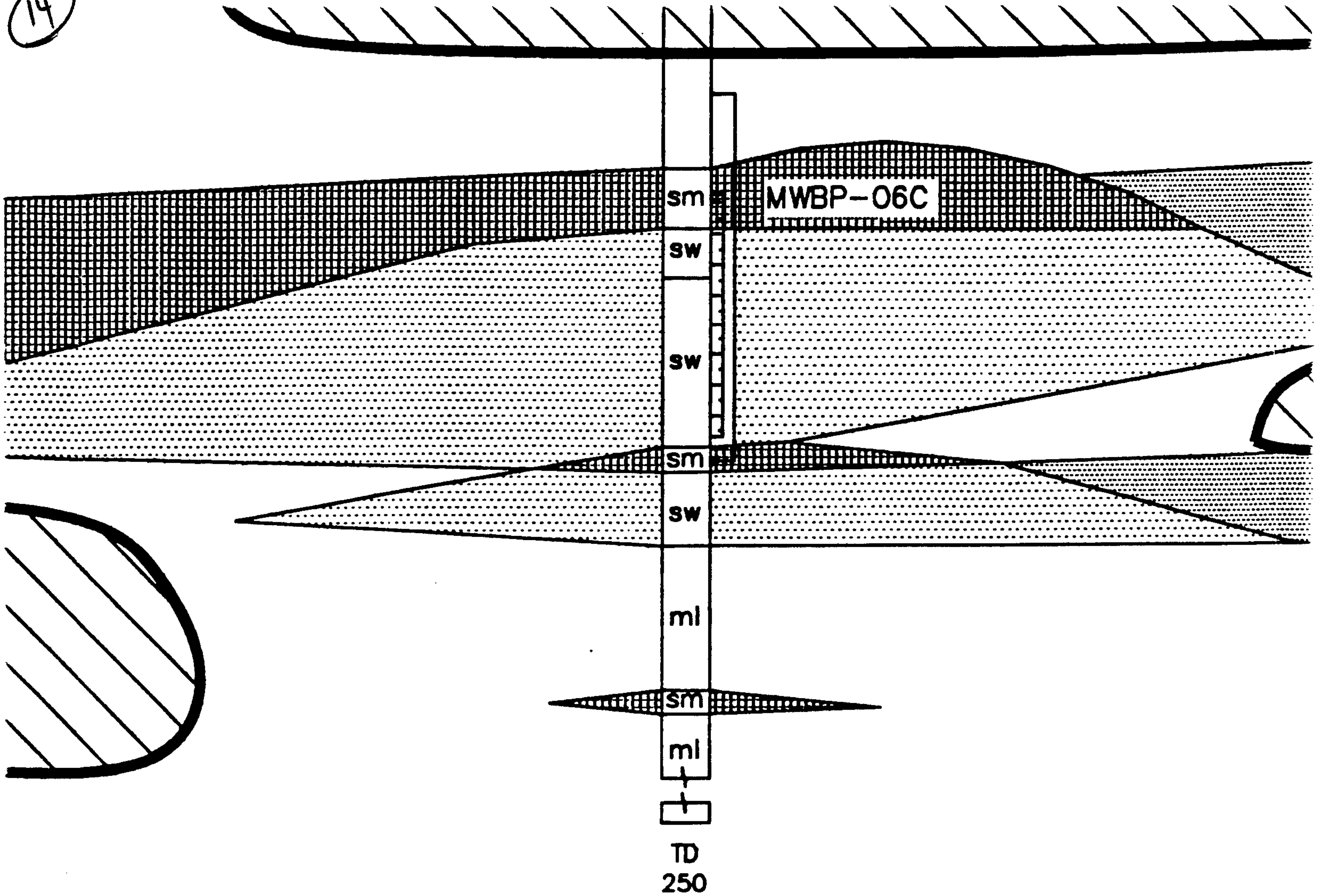

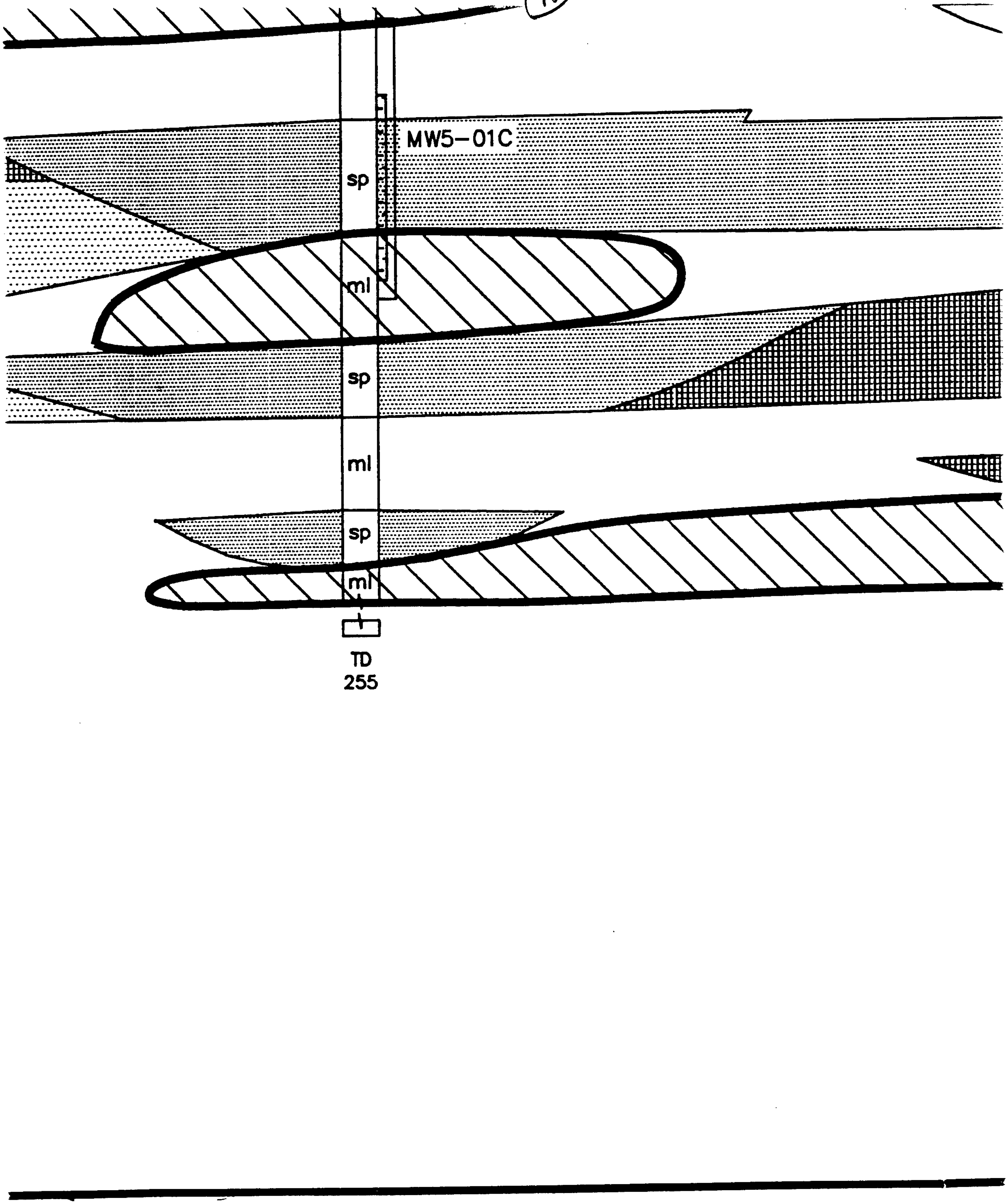
MW5-01C
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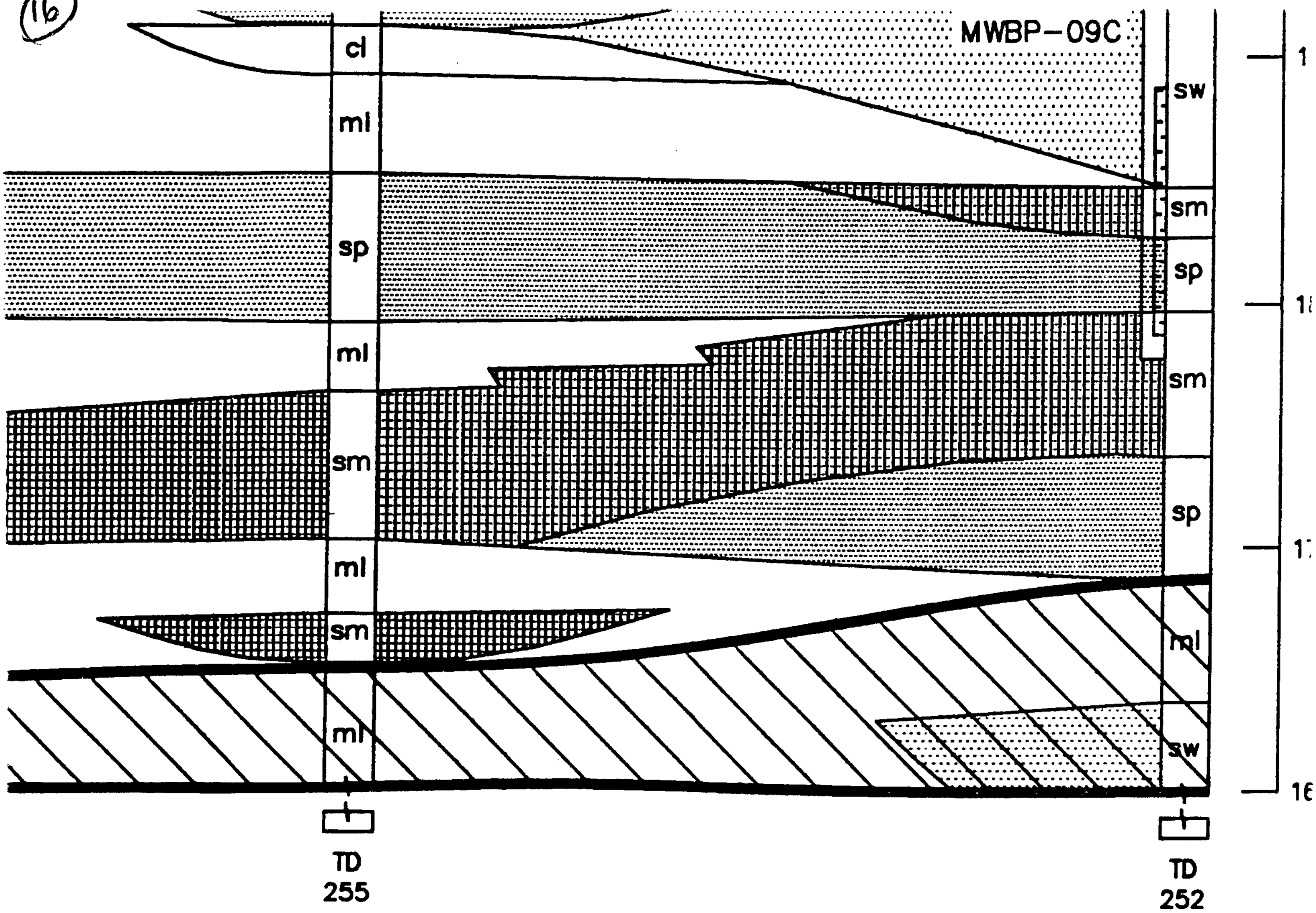
255

(16)



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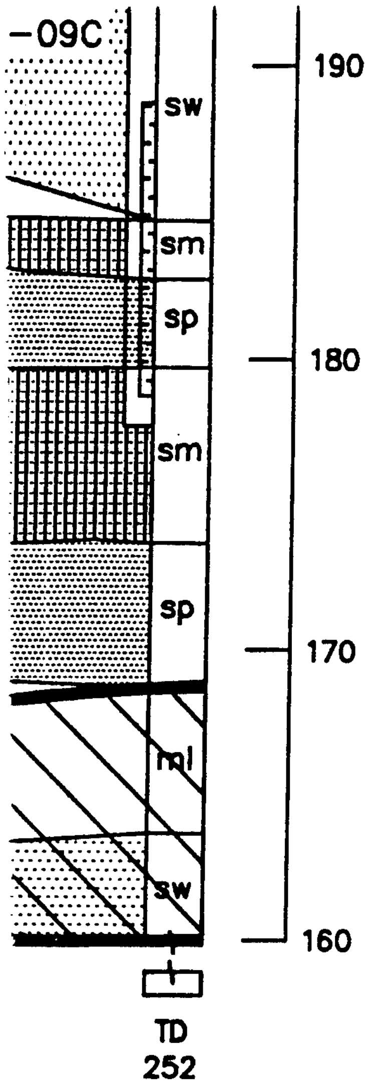

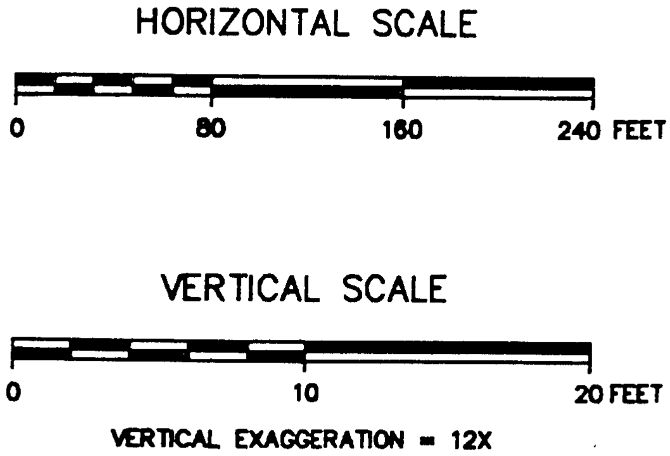

FIGURE 4-7

PUMP TEST HYDROGEOLC
SETTING

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FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL
TECHNOLOGY
CORPORATION

(18)

HORIZONTAL SCALE

0 80 160 240 FEET

VERTICAL SCALE

0 10 20 FEET

VERTICAL EXAGGERATION = 12X

GURE 4-7

IMP TEST HYDROGEOLOGIC TTING

.IFORNIA AIR NATIONAL GUARD
SNO AIR TERMINAL
SNO, CALIFORNIA

INTERNATIONAL
TECHNOLOGY
CORPORATION

elevation differences between the monitoring well screens and the Hydropunch samples, sand layers, and contaminant concentration data. Appendix B contains the well construction diagrams for each deep monitoring well. For completeness, well construction data for each existing monitoring well on Base is also provided in Appendix B.

4.5.4 Deep Monitoring Well Groundwater Sampling

Each deep monitoring well installed during the deep aquifer investigation was sampled in December 1993, approximately 3 weeks after the wells were developed. A second confirmation sampling round was conducted in February 1995. A complete round of water level measurements was collected from each monitoring well on Base prior to beginning sampling operations. At each well, the minimum purge volume was calculated based on the measured height of the standing water column in the well casing. A minimum of three well casing volumes of water were removed from each well using an environmental submersible pump. Purge rates averaged 3.5 gpm.

The pump and its discharge tubing were removed from the well after it was purged. Samples were then collected with a decontaminated Teflon bailer, and analyzed for VOCs by Methods 8010 and 8020 at a fixed-base laboratory. Deep monitoring well groundwater samples collected are listed in Table 4-5.

4.5.5 Aquifer Tests

Results of the deep aquifer investigation determined that the COC at the Base is PCE, which is detected in the uppermost water-bearing zone. PCE is detected less frequently with depth below the water table. The deep aquifer investigation provided detailed insight into the hydrogeologic regime from the water table (80 feet bgs) to a depth of 250 feet bgs. However, insufficient information regarding the interconnection of the hydrogeologic units of interest was gained from the initial investigation. Therefore, pump/aquifer tests were conducted in selected wells to determine the degree of interconnection between the units and to begin the process of evaluating a remedial strategy when, and if, this is determined to be appropriate.

Activities associated with the aquifer tests included a confirmatory round of groundwater sampling from deep wells (Section 4.5.4) in February 1995, piezometer installation, and aquifer tests in March 1995. The following sections summarize the associated field activities. Additional details are included in the draft groundwater sampling/pump test technical memorandum (IT, 1996b).

Specific objectives of the aquifer test activities were to:

- Determine the radius of influence around the pumped wells.
- Determine the aquifer parameters, transmissivity, and storativity within the radius of influence of each pumped well.
- Determine the degree of interconnection between the shallow and deep aquifer zones.

PCE is detected in the "B" series wells, but not in the "C" series wells. Therefore, should any remedial actions be required, they would focus on the water table and "B" wells/zones. Aquifer tests were performed to assess whether the "A" and "B" zones were connected. Additionally, an aquifer test was conducted in an "A" well to better determine aquifer parameters for the uppermost water-bearing unit.

The "B" well chosen for pump testing was MWBP-05B due to its location within a contaminated aquifer zone and to its proximity to other existing monitoring wells. Well MWBP-12 was the selected shallow well because it is within the water table contaminant plume.

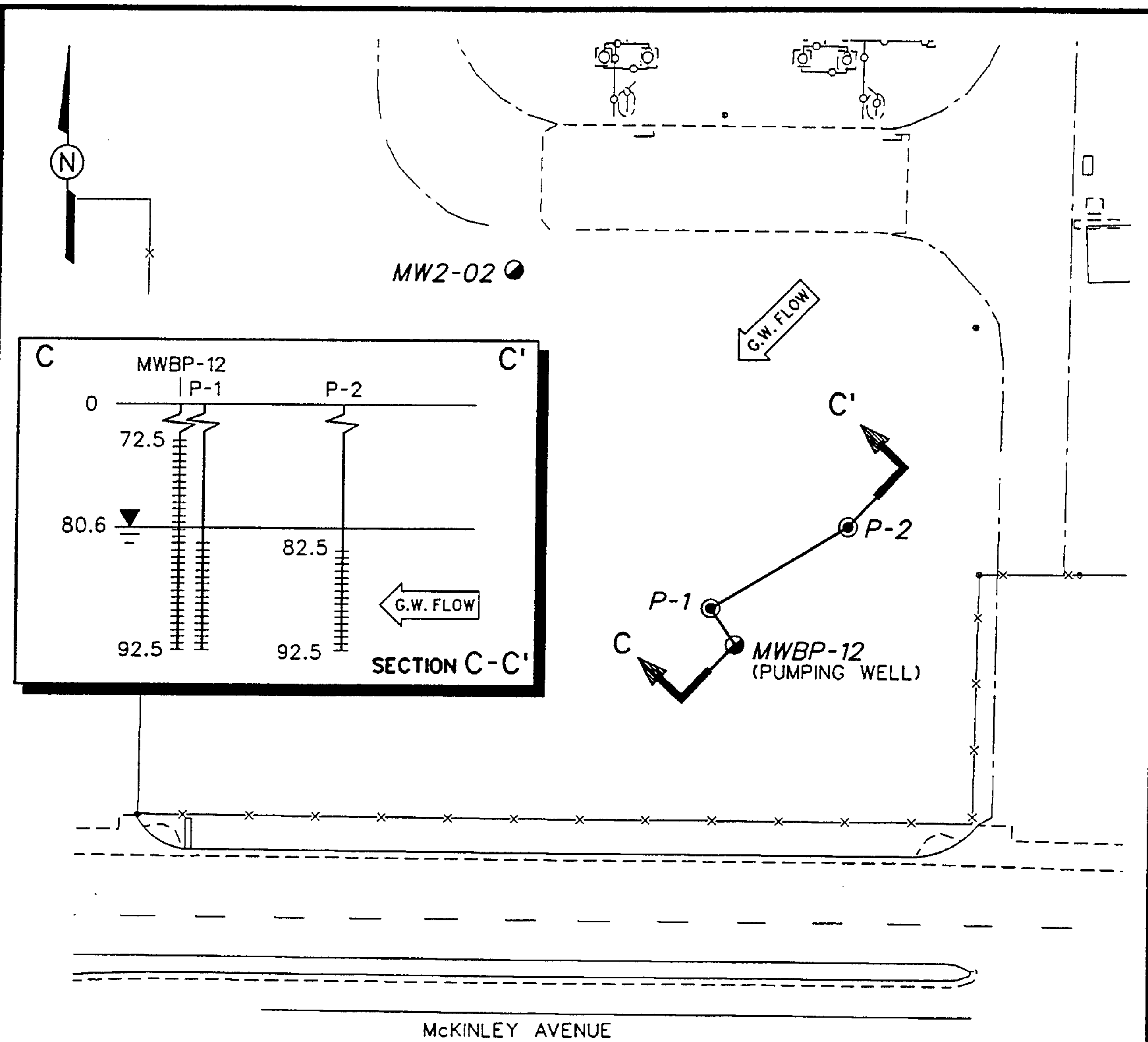
Five elements comprised the aquifer test field activities: groundwater sampling of eight existing deep monitoring wells on Base, piezometer installation, background water level monitoring, step-drawdown testing, and constant rate testing of two wells. Groundwater sampling of the deep wells is discussed in Section 4.5.4.

During deep well groundwater sampling activities, short-term "pretests," were conducted in three shallow monitoring wells (MW5-01, MW5-01 and MWBP-12). The environmental purge pump was used to incrementally stress the three wells to determine which well was better suited for more rigorous testing. Both MW5-02 and MWBP-12 were able to produce sufficient water to warrant further pump tests. However, MWBP-12, as previously noted, was the final selection due to its location within the contaminant plume. Well locations are shown in Figure 4-6.

4.5.5.1 Piezometer Installation

A total of five piezometers were installed in support of the pump tests. Two (P-1 and P-2) were installed near MWBP-12 and three (P-3B, P-4A, and P-5B) were placed near MWBP-05B. Configurations of the pumping and observation wells are shown in Figures 4-8 and 4-9. Distances of piezometers from the pumping wells were determined based on simplistic

DWG. NO.409724ES.018
PROJ. NO.:409724
INITIATOR: S.LOGAN
PROJ. MGR.:D.BURTON
DRAFT. CHCK. BY: C.TUMLIN
ENGR. CHCK. BY: S.LOGAN
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 10/13/95
DRAWN BY: D.BILLINGSLEY



SCALE
0 50 100 FEET

LEGEND:

MWBP-12 WATER TABLE MONITORING WELL

P-1 PIEZOMETER

G.W. FLOW GROUNDWATER FLOW DIRECTION

FIGURE 4-8
PUMPING TEST SETUP
AT MWBP-12

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FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

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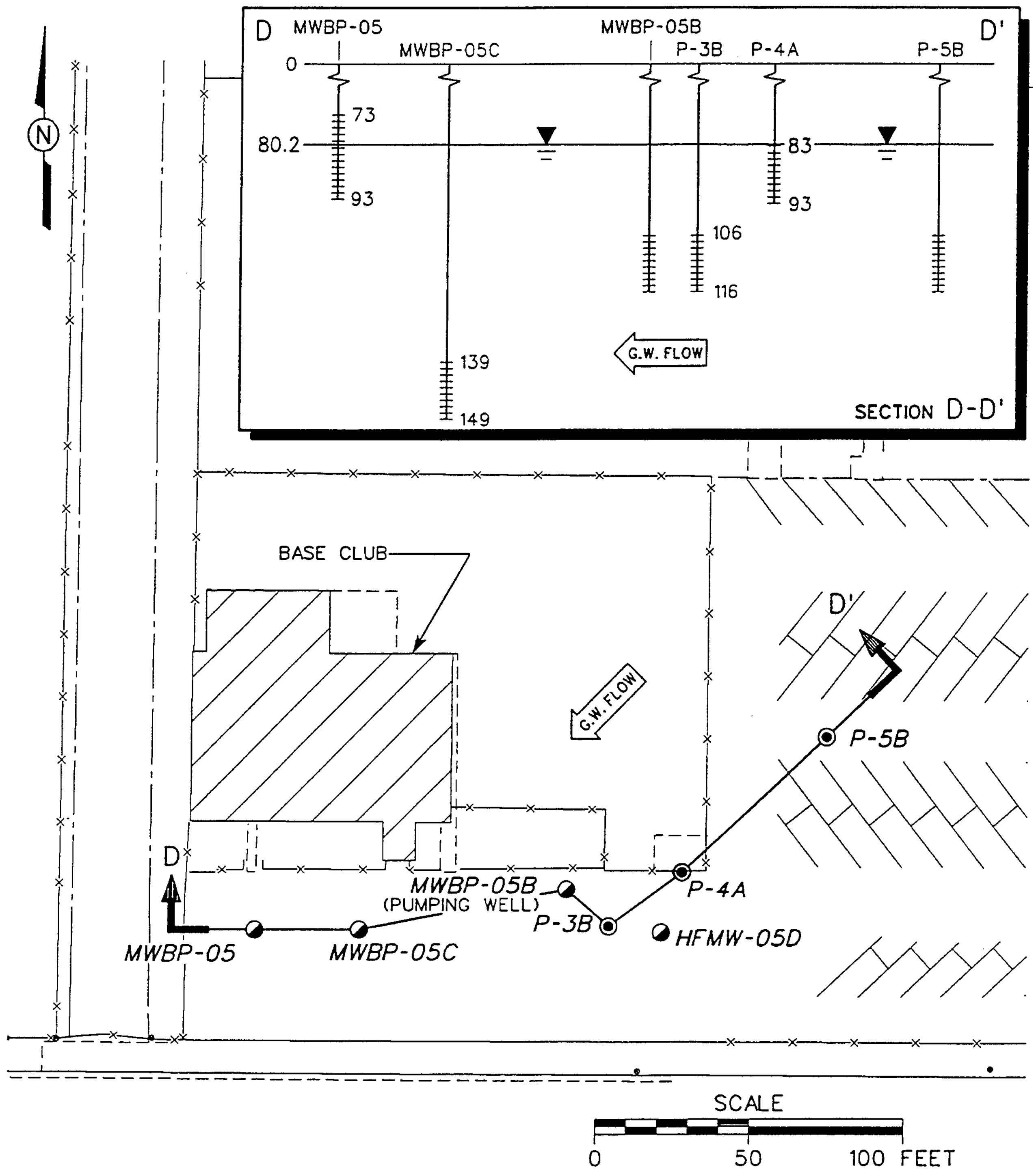

LEGEND:

MWBP-05 MONITORING WELL

P-3B PIEZOMETER

G.W. FLOW GROUNDWATER FLOW DIRECTION

FIGURE 4-9
PUMPING TEST SETUP
AT MWBP-05B

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DWG. NO.409724ES.019 | PROJ. NO.:409724
INITIATOR: S.LOGAN | PROJ. MGR.:D.BURTON
DRAFT. CHCK. BY: C.TUMLIN | ENGR. CHCK. BY: S.LOGAN
DATE LAST REV.: | DRAWN BY:
STARTING DATE: 10/13/95 | DRAWN BY: D.BILLINGSLEY

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modeling of aquifer stresses using preliminary hydrogeologic parameters from slug tests, well purging information, and short-term pretests. Piezometers were placed such that one would show a definite water level response and one would be near to the outer extent of the radius of influence from pumping.

Piezometers were constructed with 1.5-inch OD PVC screen (0.010-inch slot) and casing. Screen lengths were 10 feet. Depths of piezometers were predetermined based on the desired zone to be monitored. Piezometers at MWBP-12 were installed to a depth identical to that of MWBP-12 (92.5 feet bgs). Piezometers P-3B and P-5B were installed to the same depth as MWBP-05B (116 feet bgs). Existing shallow well MWBP-05 (Figure 4-9) was installed to a depth of 93 feet bgs; piezometer P-4A was installed to this same depth. These two shallow wells provided shallow-zone drawdown measurements and allowed for the determination of the connection between the A and B aquifer zones. Table 4-7 lists information for wells and piezometers utilized during the pump tests. Piezometer construction specifications are provided in Appendix B.

4.5.5.2 Background Water Level Monitoring

The shallow and intermediate depth zones of the uppermost aquifer were selected for pump testing. To monitor ambient groundwater level fluctuations during the tests, continual water level monitoring was conducted in a water table well and the B well (MWBP-09 and MWBP-09B, Figure 4-6). Pressure transducers were installed into these two wells and measurements were recorded every 20 minutes with a data logger. Verification of fluctuations were made with periodic manual water level measurements.

Background monitoring began on March 16, 1995; the first pump tests began on March 21. A break in background monitoring was necessary due to Base activities on March 25 and 26. Ambient monitoring was reestablished before the pump tests continued on March 27, 1995. In addition to the water level measurements, records of hourly barometric pressure data were obtained for the testing period from the National Weather Service office located immediately north of the Fresno Air Terminal.

4.5.5.3 Step-Drawdown Tests

Step-drawdown tests were conducted in MWBP-12 and MWBP-05B on consecutive days. Drawdown measurements were recorded in the pumping well and nearby piezometers with a pressure transducer and data logger. Table 4-8 lists the pumping rate steps, the step duration, and drawdown measured in the pumping well.

Table 4-7

Piezometer Construction Summary
California Air National Guard - Fresno, California

Piezometer/Well ID	Installation Date	Ground Surface Elevation[a]	Screened Interval[b]	Distance from Pumping Well (feet)	Northing	Easting
MWBP-12	9-22-92	320.8	72.5 - 92.5	0	2162553.0	6352214.7
P-1	3-16-95	320.9	82.5 - 92.5	15	2162565.3	6352206.4
P-2	3-17-95	320.8	82.5 - 92.5	50	2162588.9	6352248.7
MW2-02	10-2-90	321.3	72 - 92	130	2162663.5	6352146.5
MWBP-05B	11-8-93	320.5	106 - 116	0	2162545.7	6351838.1
P-3B	3-13-95	320.7	106 - 116	20	2162533.6	6351853.7
P-4A	3-14-95	321.5	83 - 93	40	2162551.9	6351877.4
P-5B	3-15-95	321.7	106.1 - 116.1	99	2162595.6	6351923.1
MWBP-05	10-25-90	320.3	73.1 - 93.1	102	2162531.1	6351737.2
MWBP-05C	11-7-93	320.3	139.2 - 149.2	69	2162531.7	6351770.9

[a]Feet mean sea level.
[b]Feet below ground surface.

Table 4-8

Step-Drawdown Test Summary
California Air National Guard - Fresno, California

Well ID	Step Number	Step Duration (min)	Pump Rate (gpm)	Maximum Drawdown (feet)	Specific capacity (gpm/ft)[a]
MWBP-12	1	30	2.5	1.48	1.69
	2	50	5	3.24	1.54
	3	70	6.5	5.02	1.29
	4	60	7[b]	5.63	1.24
MWBP-05B	1	45	6	37.3	1.61
	2	130	12	7.84	1.53
	3	70	18	13.13	1.37
	4	30	19[b]	13.84	1.37

[a]Specific capacity = pump rate/drawdown.
[b]Maximum pump output.

The wells were pumped with a 4-inch submersible pump and flow rates were measured with an in-line flow meter. Extracted groundwater was treated with a portable activated carbon treatment system and the treated water was stored at the well head in a 7,000-gallon tank for later disposal. Samples of the extracted groundwater were collected before and after treatment to assess the effectiveness of the contaminant removal.

Pumping rates were selected while the test was in progress to adequately stress the aquifer. The information obtained from these tests was used to provide the optimal pump rate to be used during the constant rate tests.

4.5.5.4 Constant Rate Tests

Constant rate tests were performed after the step-drawdown tests were conducted and evaluated in the respective pumping wells. Pressure transducers were placed into several nearby observation wells during the tests. Pump discharge rates, selected based on the results of the step-drawdown tests, were kept constant for the duration of the tests. Extracted water was again treated through the activated carbon system and the treated water was temporarily stored before it was released.

Well MWBP-12 was pumped at 7.5 gpm for a period of 20 hours. Drawdown measurements were recorded automatically in the pumping well and in P-1 and P-2. Manual measurements were collected periodically from wells MW2-02 and MW2-03 (Figures 4-4 and 4-8). Due to excessive drawdown in MWBP-12, the test was stopped after 20 hours; the original intent was to conduct the test for 36 hours. From the step-drawdown test, it had appeared as though MWBP-12 could sustain a rate of 7 to 8 gpm. Unexpectedly, the aquifer was dewatered.

Well MWBP-05B was pumped at 16 gpm for 36 hours. Drawdown measurements were electronically recorded in P-3B, P-4A, P-5B, and HFMW-05D. The latter well was installed as a part of the more regional Old Hammer Field investigation. Manual measurements were collected periodically from MWBP-05 and MWBP-05C (Figure 4-9).

4.6 Data Validation

Data validation is the systematic review of reported analytical data to ensure the reliability and to define the usability of the data. The U.S. Environmental Protection Agency (EPA) defines data validation as the systematic process that consists of data editing, checking, auditing, verifying, and reviewing to ensure that the data are adequate for their intended use. Validation methods for organic analyses review QC elements such as initial calibration runs,

continuing calibration checks, laboratory method blank results, and laboratory spikes and duplicate analyses. In addition, holding times are reviewed and surrogate recovery data are evaluated. "Raw" data packages are also reviewed to verify completeness of the reporting requirements.

When laboratory situations are present that do not meet the standards set in EPA guidance documents, results may be flagged with various data qualifiers which denote various conditions. Over the span of the project, validation has been conducted according to the latest guidelines at the time of implementation (EPA 1988a; 1988b; 1993; 1994a). For organic analyses, the following qualifiers may be added to results:

U - The analyte was analyzed but was not detected exceeding the reported sample quantitation limit.

J - The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

N - The analysis indicates the presence of an analyte for which there is presumptive evidence to make a tentative identification.

NJ - The analysis indicates the presence of an analyte that has been tentatively identified and the associated numerical value represents its approximate concentration.

UJ - The analyte was not detected exceeding the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R - The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified.

4.6.1 Site 5-BCP Investigation Validation

Screening data collected during the Site 5-BCP RI (SOV, borehole groundwater samples, soil screening samples) were not subjected to validation. Validation is not generally required for screening data (Level B-type) due to the method of collection and the ultimate use of the data. All of the soil and groundwater samples submitted to the fixed-base laboratory were validated to HAZWRAP Level D standards.

4.6.2 Quarterly Groundwater Sampling Validation

Due to the volume of samples analyzed in association with this activity, 10 percent of the groundwater samples submitted for analysis were validated to Level D standards. Based on the findings of the validation during each quarter, no deficiencies were noted in the validation summary reports and the data from each quarter are usable to their full extent.

4.6.3 Deep Aquifer Investigation Validation

As with the Site 5-BCP investigation, the deep aquifer investigation screening data (soil and groundwater samples analyzed with the field GC) were not subjected to validation. The groundwater screening samples were prepared and analyzed using standard methods; the only qualification of the data was that they were not analyzed at a fixed-base laboratory. Otherwise, this data could have been considered either Level C or Level D data, depending on the type of backup provided. All of the groundwater samples collected from the monitoring wells during the deep aquifer investigation were validated to Level D criteria.

4.7 Investigation-Derived Waste

As a part of each field effort, the management of IDW was a general focus. Before each field effort began, guidelines and criteria were in place to allow for the disposal of waste soil, wastewater, field laboratory waste, and other miscellaneous refuse. Disposal of soil and water from investigation activities were all dependent upon site-specific data. This focus on IDW issues makes it possible for IDW to be handled in a timely and competent manner in order to avoid future problems and liabilities associated with waste materials.

4.7.1 Waste Soil Disposal

All waste soil cuttings and excess soil sample material were collected in labeled drums to await final disposal. This was done for both RI field efforts. Periodic soil screening samples collected during both investigations were used to determine if the soil could be emptied and spread on Base, or would need to undergo further testing prior to disposal. As specified in the SAP addenda (IT, 1992b; 1993a), if field screening analyses were below a certain level (2 parts per million [ppm] total VOCs), then it was agreed that the soil could be disposed of on Base. This was the case for all of the waste soil generated during both field efforts.

In boreholes where soil screening samples were not collected (e.g., monitoring well boreholes), screening data from nearby borings were used as surrogate data. All soil material generated from the 12 borings and 6 monitoring wells associated with the Site 5 investigation (approximately 36 cubic yards [yd^3]), and from 5 exploratory borings and 8 monitoring wells

associated with the initial deep aquifer investigation (approximately 37 yd^3) were emptied and spread on Base at a designated area near to the decontamination pad.

4.7.2 Wastewater Disposal

Wastewater was generated during each effort and consisted of decontamination water, well development water, and well purging water. All of the water was collected in temporary storage tanks at the decontamination pad, except for a portion of the water generated during the quarterly sampling events. Water from the last quarterly sampling event was discharged into the decontamination pad sump and allowed to evaporate over time. A batch wastewater discharge permit through the City of Fresno Waste Water Management District (permit BP 02-90) was obtained during the SI activities and was approved for extensions during all following efforts.

When a tank was full, or if field activities were nearing completion, the tank(s) was sampled for the parameters specified in the discharge permit (VOC, metals, pH, cyanide, oil, and grease). Analytical results were forwarded to the City of Fresno for their review, and permission to discharge was given. A discharge hose was connected to the tank and was run to a nearby sanitary sewer access. All water was released to the sanitary sewer. In this manner, approximately 5,000 and 20,000 gallons of water were released during the Site 5 and deep aquifer investigations, respectively.

Water extracted during the pump test activities was immediately treated at the well head with an activated carbon system. The system consisted of two 55-gallon activated carbon units that were used in series: the first drum was for primary contaminant removal and the second was used as a polishing unit. Influent and effluent samples were collected during step-drawdown tests in both MWBP-12 and MWBP-05B, and were analyzed for VOCs by Methods 8010 and 8020. Influent sample results showed low levels of contaminants; effluent samples did not.

Wastewater sample results demonstrated that the treatment system was working properly. Wastewater was then released to Site 5-BCP through a series of piping laid out across the Base. All of the wastewater was disposed of in this manner after it had been treated through the activated carbon system.

4.7.3 Equipment and Protective Clothing Disposal

All disposable equipment and protective clothing, such as rope, plastic sheeting, latex gloves, etc. were collected in double-lined garbage bags, which were then placed in industrial dumpsters for disposal in the sanitary landfill. As appropriate, equipment was rinsed prior to being placed into garbage bags.

4.7.4 Field Laboratory Waste Disposal

All spent equipment, extraction solvents, and calibration standards used in the field laboratory were collected into a 20-gallon drum and were properly packed. Items placed in the drums included waste methanol, glass pipettes, beakers, microsyringes, and soil extract excess. All items were listed on an inventory that was attached to the outside of the drum, with a copy also placed inside the drum. One drum of waste was generated for each of the Site 5 and deep aquifer investigations. The drums were relinquished to the Base for inclusion with their routine hazardous waste inventory for disposal.

5.0 Site-Specific Hydrogeology

5.1 Basewide Hydrogeology

The investigations associated with the RI were not designed to refine the hydrogeologic regime across the entire Base. However, this section is adopted from the SI report (IT, 1992a) to provide relevant background information to supplement Sections 5.2 and 5.3 and to afford more detailed migration analyses in Section 8.0.

The geology beneath Fresno ANG from ground surface to the water table (80 feet bgs) is characterized by alluvial fan deposits that have been shown to be vertically and horizontally heterogeneous. Specific beds are localized in extent. A hardpan layer is present near ground surface, at depths ranging from 4 to 7 feet bgs. Its presence and thickness across the Base varies; at places, it is only 3 feet thick and in others, its extends to depths of 18 feet bgs.

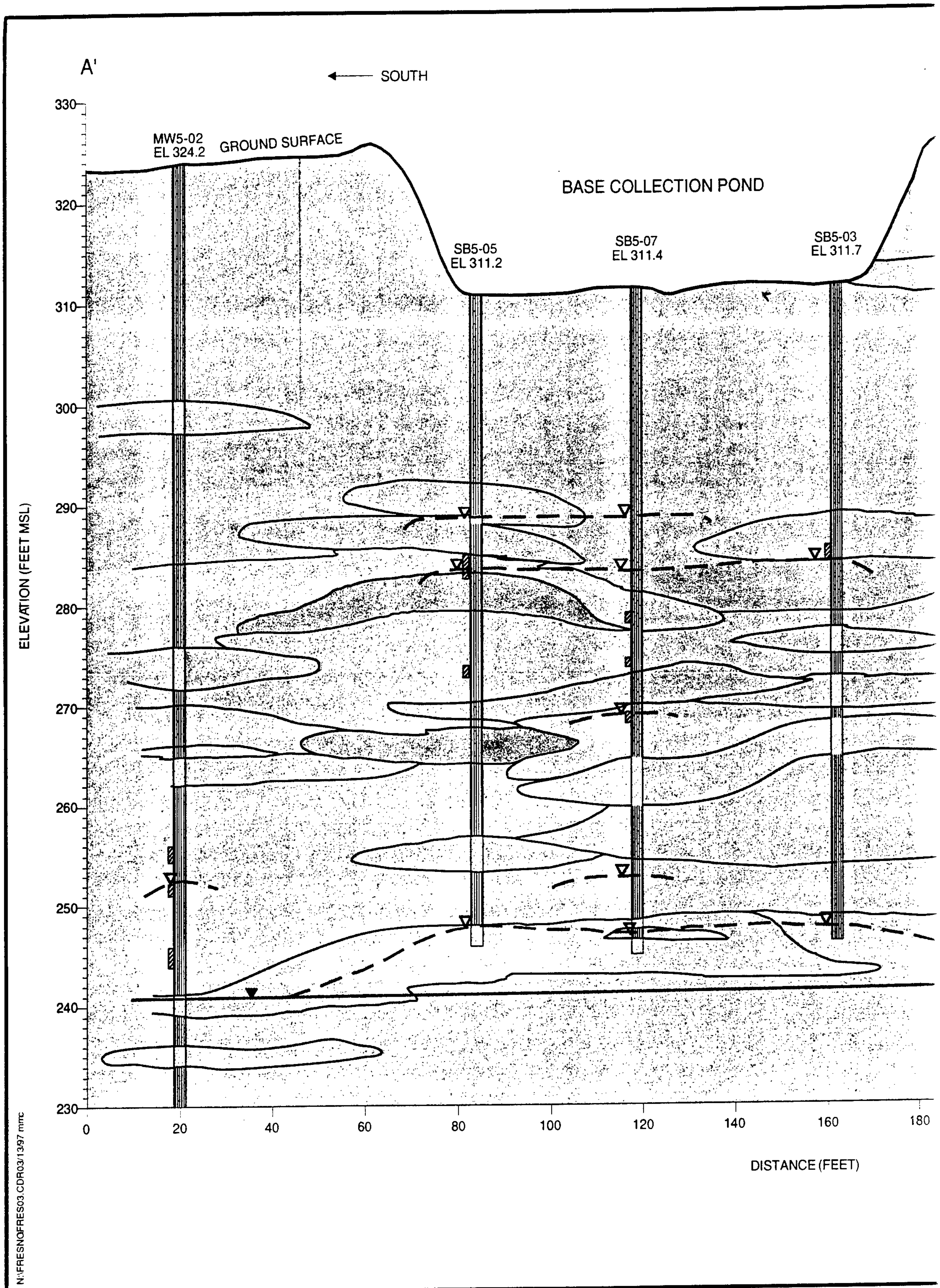
Much of the subsurface is composed of levee and overbank deposits that comprise brown, dark, reddish, and olive-brown poorly sorted silts, silty sands, clayey fine sands, and brown and olive-brown to olive-gray well sorted fine silty clays. Fine-grained silty sands and sandy silts dominate the subsurface environment. Coarse-grained deposits were only sporadically encountered. The uppermost water-bearing zone is typically comprised of silty sands. The SI did not attempt to identify the thickness of the water table sediments.

Groundwater elevation measurements of the uppermost water-bearing zone show that shallow groundwater flows predominantly from the northeast towards the southwest across the Base. A series of groundwater contour figures for selected events is in Appendix E. Appendix E also contains a compilation of groundwater elevation measurements at each well over the history of the project.

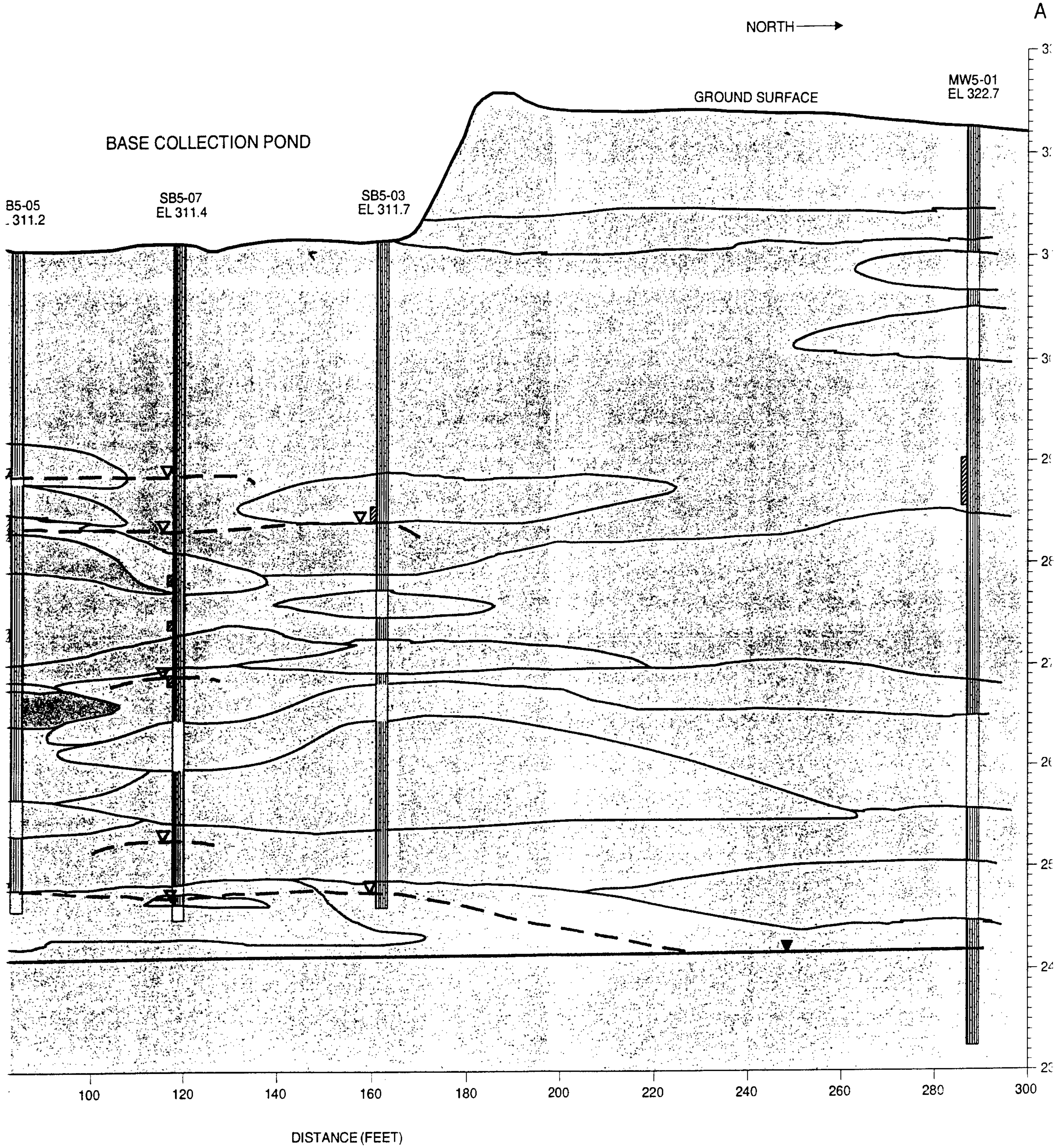
5.2 Site 5-BCP Hydrogeology

Detailed boring logs from five boreholes were used to construct a geologic cross section across Site 5-BCP (Figure 5-1; see Figure 4-3 for soil boring locations). Boring logs are included in Appendix F. The stratigraphic intervals delineated in the figure were defined in terms of the USCS. This classification system is divided into sediment types encompassing a broad range of grain sizes.

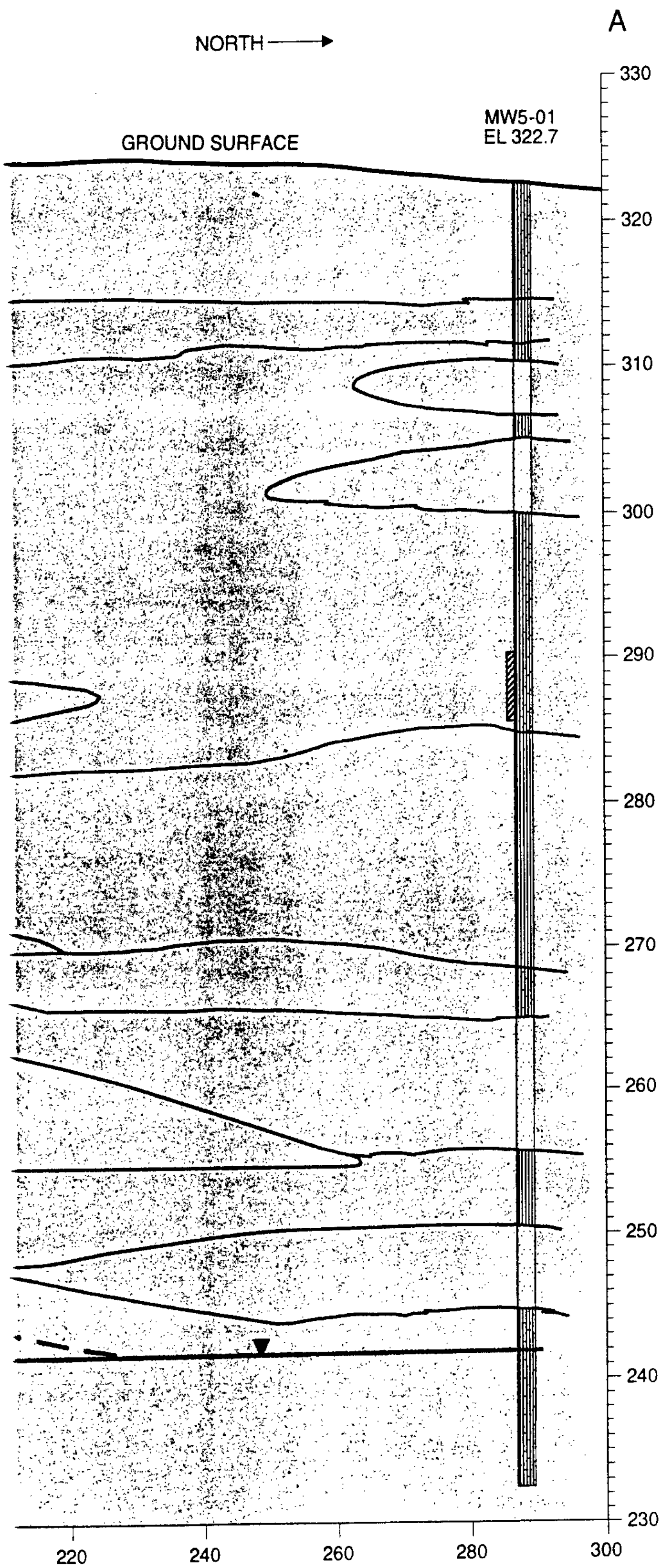
Because of the broad groupings, coarse sand seams within a silty sand unit, or pure silts within a sandy silt body, are not able to be easily shown. The classifications are repre-



A'
SOUTH
MW5-02
EL 324.2
GROUND SURFACE
BASE COLLECTION POND
SB5-05
EL 311.2
SB5-07
EL 311.4
SB5-03
EL 311.7
ELEVATION (FEET MSL)
330
320
310
300
290
280
270
260
250
240
230
0
20
40
60
80
100
120
140
160
180
DISTANCE (FEET)
N:\FRESNO\FRES03.CDR03/13/97 mmc



A
NORTH
GROUND SURFACE
MW5-01
EL 322.7
BASE COLLECTION POND
B5-05
311.2
SB5-07
EL 311.4
SB5-03
EL 311.7
100
120
140
160
180
200
220
240
260
280
300
DISTANCE (FEET)



LEGEND:

- WATER TABLE
- WETTING FRONT
- CEMENTED ZONE
- SAND (sp)
- SILTY SAND (sm)
- SILT, SANDY SILT (ml)
- BROWN, LIGHT BROWN, REDDISH BROWN
- GRAY, GRAYISH BROWN

HORIZONTAL SCALE:

0 20 40 FEET

VERTICAL SCALE:

0 10 20 FEET

VERTICAL EXAGGERATION: 2X

FIGURE 5-1

HYDROGEOLOGIC CROSS SECTION A-A', BASE COLLECTION POND

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

sentative of general materials, but are not able to reconstruct the discrete systems operating at the time of deposition. Also, the soil sampling program was not focused on studying every minute facies change, but was set up to determine definite stratum breaks or changes, and soil material types.

Figure 5-1 shows the types of strata underlying Site 5-BCP. As established during the SI, sand bodies are laterally discontinuous, which is characteristic of an alluvial environment. Silty sands are much more extensive and these units undoubtedly contain zones of coarser-grained and finer-grained materials. Also of interest is what appears to be a fairly continuous fine-grained silt and sandy silt layer from 250 to 255 feet (elevation) in MW5-01, SB5-03, and SB5-07, which grades into a thicker sequence in SB5-05 and MW5-02, ranging from 241 to 263 feet in elevation. The cross section also shows the interbedding or interfingering of materials, especially in SB5-05 and SB5-03: isolated sand units occur in silts, and isolated fine-grained deposits occur within thicker silty sand deposits.

The cross section depicts the heterogenous nature of the deposited materials. Several fine-grained layers would inhibit the downward migration of chemicals. Water would tend to move along the contact between the coarse-grained and lower fine-grained layer until a silty sand or sand is encountered, and then would move downward in the more porous material. Several layers were described as sandy silts, which would suggest that water would not just move along its upper contact, but would also permeate into it and move through it, due to the sand content. The only continuous fine-grained layer (predominantly a sandy silt) is near the bottom of the boreholes, mentioned in the previous paragraph. Similarly, no (clean) sand bodies are vertically and laterally extensive across the area. Their sporadic occurrence would not suggest that a preferential avenue for contaminant migration exists in the subsurface.

Figure 5-1 also includes zones that exhibited some degree of cementation, as well as areas of increased moisture. The cemented layers show no pattern or consistency in occurrence. Cementation occurs in both fine-grained and sandy materials, but they do not seem to be laterally connected. One commonality, however, is that several of these cemented layers do occur along zones of increased moisture. This tends to suggest that the cementation collects percolating water until a near-saturated condition exists, allowing the water to move downward. Yet, being disconnected, the cementation does not force water to move horizontally in any preferential direction.

The zones of increased moisture have been given the term "wetting front," primarily due to observations made during drilling. Soil material recovered from these intervals exhibited a condition near to saturation. Additionally, drilling and sampling equipment also appeared wet when they were brought to the surface. However, when attempts were made to collect a water sample from one of these zones, no freestanding water accumulated. One borehole was left open at the wetted zone for approximately 14 hours, but no water was observed. This led to the conclusion that the majority of the pores are filled with water, but the soil is not fully saturated. It was then characterized as precipitation or other water that was migrating towards the water table as a wetting front.

Several wetting fronts are noted on Figure 5-1. Two are observed at similar elevations in at least two borings. Two others are localized to the middle of Site 5-BCP, in SB5-07. The wetting fronts are present outside Site 5-BCP boundaries and were observed in MW5-02, SB5-08, and SB5-09 at various depths (see boring logs in Appendix F and boring locations in Figure 4-3). Borings MW5-01 and SB5-11 did not show any evidence of wetting fronts.

Water table measurements from the two monitoring wells are shown in the cross section. When the observations of standing water at the bottom of the inner borings are combined with the measured elevation data, they show that Site 5-BCP is a local recharge area for the water table. This is corroborated with wetting front observations.

The stratigraphy underneath Site 5-BCP, combined with the wetting front observations and water table measurements, indicate that water entering Site 5-BCP travels to the water table along varying paths. Water travels on top of and through fine-grained layers, and through the sandy materials until the water table is reached. But water will tend to move outwards from Site 5-BCP for a short distance towards the west and south before entering the groundwater system. It is believed that the wetting front observed in MW5-02 (at an elevation of 252 feet) is near the outer extent of lateral percolation. Therefore, water, while moving downwards, will also tend to move outwards for a distance of approximately 100 feet south, and southwest before encountering the water table.

In 1995, the BCP was filled in to grade with clean fill material. The three outfall pipes used to drain washdown water and storm runoff from across the Base to the BCP were cut off and plugged. Obviously, the BCP is no longer a collection basin and large amounts of water will not be introduced through it. Therefore, percolation will be essentially negligent and the pore water that is currently present in subsurface soil will likely reach an equilibrium condition in

soil moisture content and not migrate to the water table. Within the next 10 years, the former BCP will be converted into an aboveground storage tank farm and will be capped with asphalt or concrete. This will completely eliminate infiltration through underlying soils.

Table 5-1 presents the results of the slug tests performed in the wells installed in 1992. Also shown is the calculated conductivity from well MW2-01, which is very close to Site 5-BCP (Figure 4-3). To estimate the average interstitial groundwater flow velocity (v) at Site 5-BCP, the following equation may be used:

$$v = \frac{(K \times i)}{n}$$

where K is the hydraulic conductivity, i is the hydraulic gradient from MW5-01 to MW2-01, and n is the porosity of the formation. From groundwater elevation measurements collected from October 1992 through February 1995, the average hydraulic gradient is 0.0030. The geometric mean of hydraulic conductivity values for the three wells in the area is 38.4 feet per day. An aquifer sample collected from MW5-01 had a measured porosity of 60 percent, whereas it is estimated that the effective porosity is 0.40. With a porosity of 0.40, the average interstitial flow velocity in the Site 5 area is approximately 105 feet per year.

5.3 Deep Aquifer Hydrogeology

Deep aquifer hydrogeology at the Base is interpreted from geologic and hydrologic data derived from the deep aquifer investigation. The geology, interpreted from the exploratory borings, provided the framework for interpretation of the hydrogeologic regime. Monitoring well installations, based on the interpreted hydrology, provided confirmatory data from which to determine potential migration pathways and to explain the observed distribution of contaminants. The geologic and hydrologic interpretations provide a basis for the discussion of investigation findings in Chapter 6.0.

5.3.1 Saturated Zone Geologic Interpretation

The deep aquifer geologic interpretation focuses on the geologic section below the water table; at elevations below 250 feet mean sea level (msl) (75 feet bgs). Figure 5-2 presents the abbreviated geologic section with the vadose zone omitted. The geologic interpretation integrates boring logs and available geophysical logs to provide a detailed cross section that traverses the site on a southwest-northeast profile. The profile is approximately 2,100 feet long, with four of the borings (EXB-01, EXB-02, EXB-03, and EXB-05) roughly on line and

Table 5-1

Slug Test Results, Site 5-BCP RI
California Air National Guard - Fresno, California

Area	Well ID	Hydraulic Conductivity, K	
		ft/day	cm/s
Base Perimeter	MWBP-09	23.8	8.4×10^{-3}
	MWBP-10	26.9	9.5×10^{-3}
	MWBP-11	17.9	6.3×10^{-3}
	MWBP-12	Not available	
Site 5-BCP	MW5-01	17.3	6.1×10^{-3}
	MW5-02	40.2	1.42×10^{-2}
	MW2-01	81.5	2.88×10^{-2}
	Geometric mean[a]	38.4	1.36×10^{-2}

[a]Geometric mean of wells MW5-01, MW5-02, MW2-01.

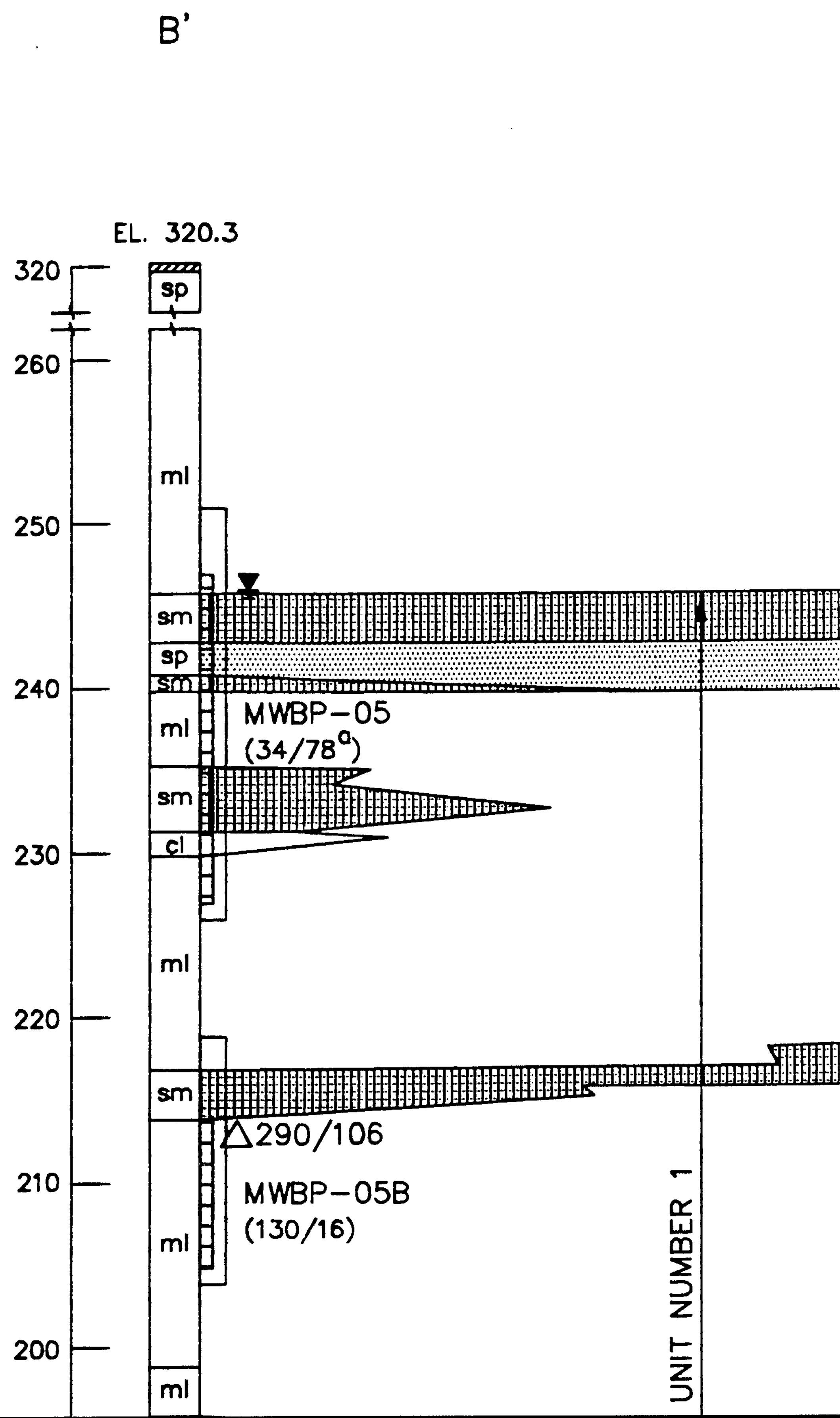
DRAWING NO.: 409724-D-139

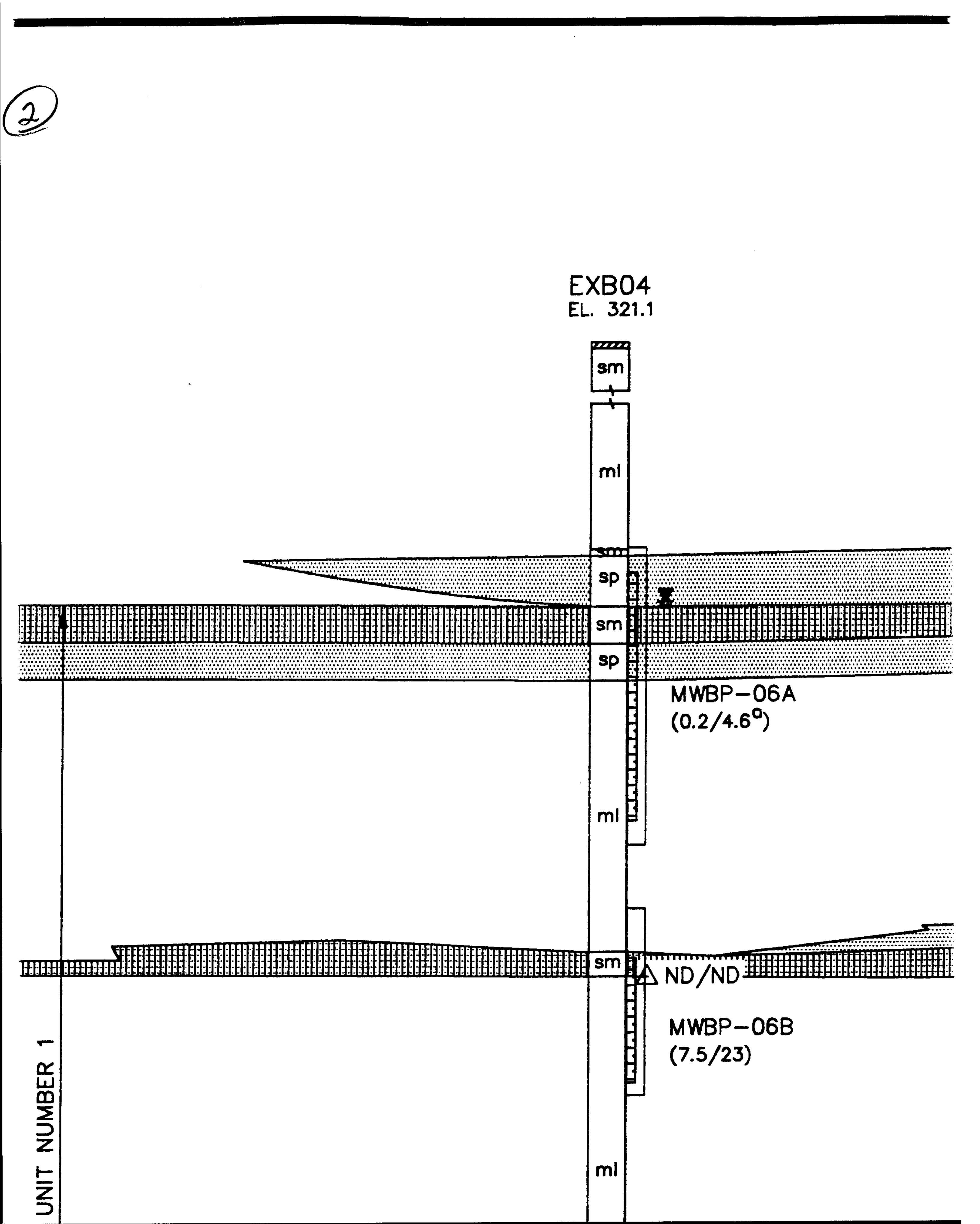
PROJECT NO.: 409724

NITIATOR: S. LOGAN

ROJECT MGR.: D. BURTON

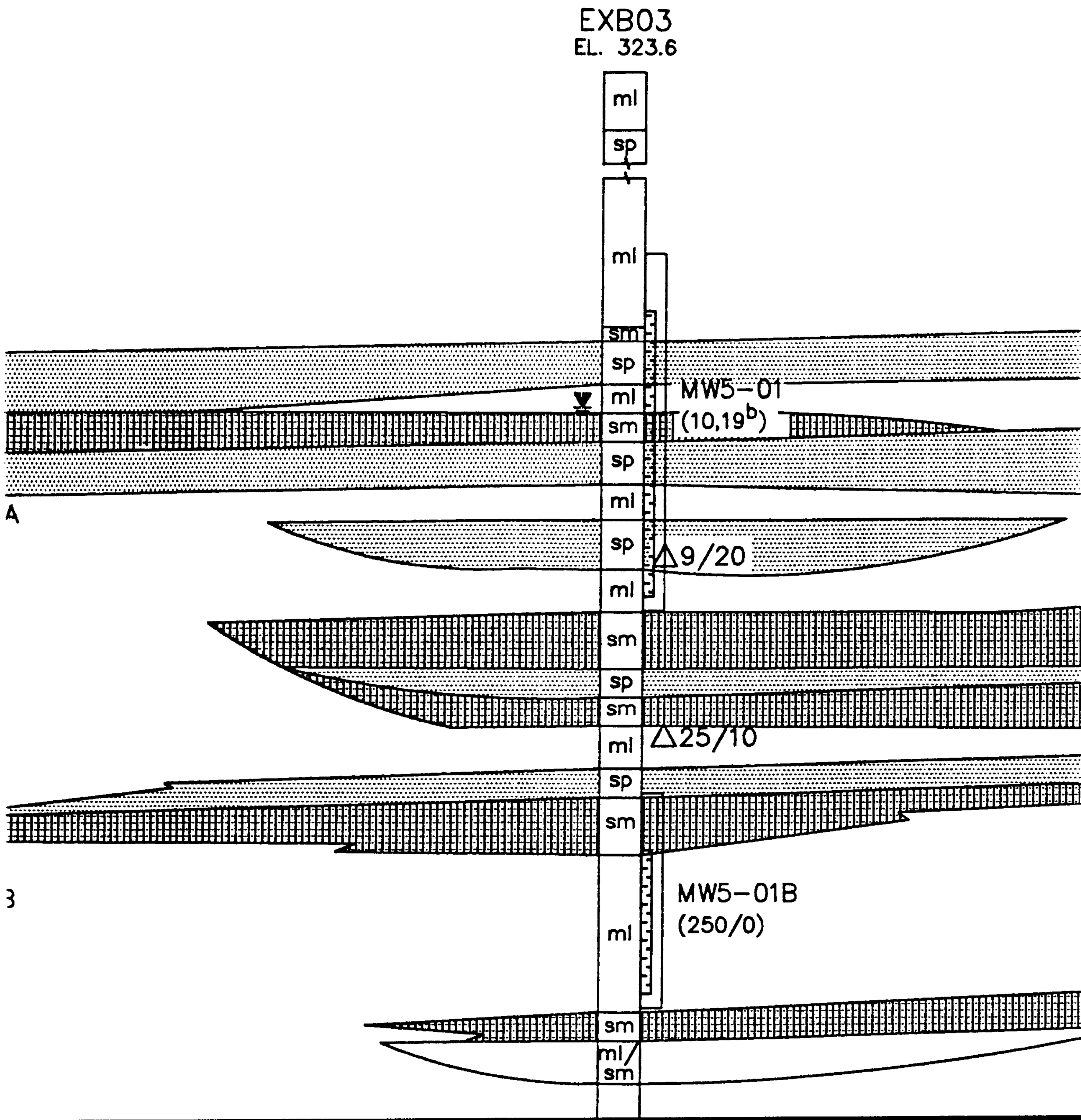
1





2
EXB04
EL. 321.1
sm
ml
sm
sp
sm
sp
MWBP-06A
(0.2/4.6a)
ml
sm
ND/ND
MWBP-06B
(7.5/23)
ml
UNIT NUMBER 1

3



EXB03
EL. 323.6
ml
sp
ml
sm
sp
ml
MW5-01
(10,19b)
sm
sp
ml
A
sp
9/20
ml
sm
sp
sm
ml
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sp
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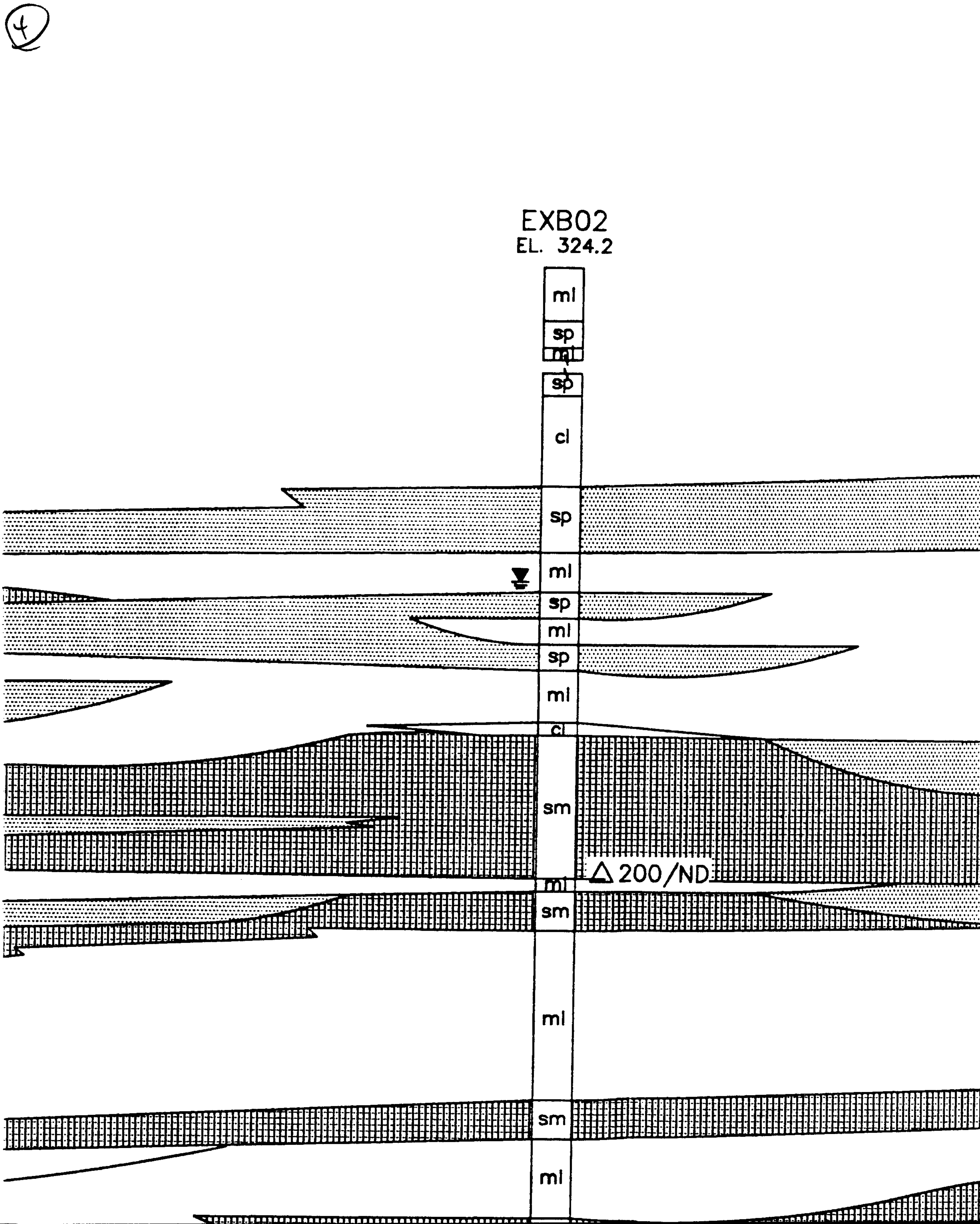
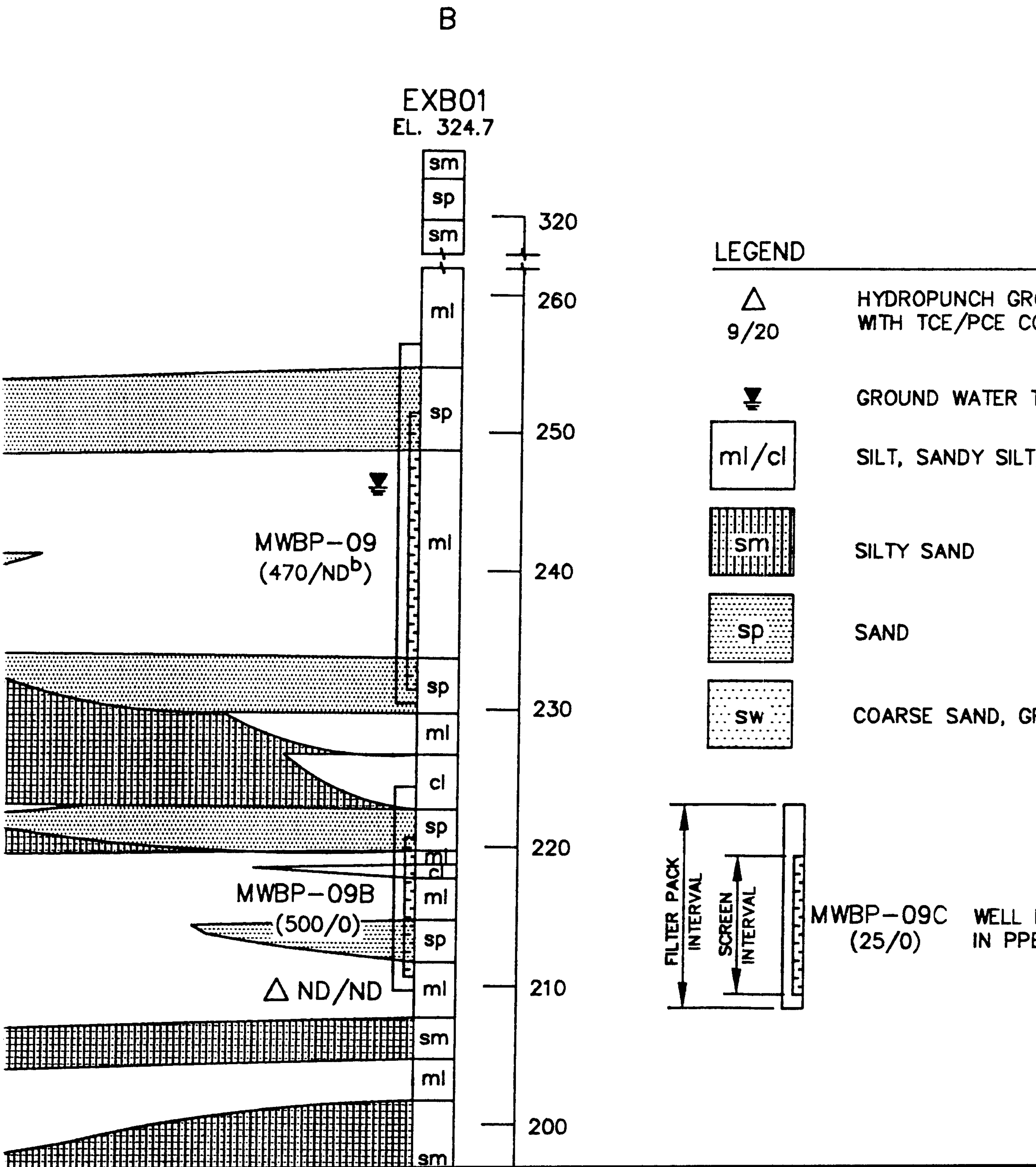
B
ml
sm
ml/sm



4
EXB02
EL. 324.2
ml
sp
ml
sp
cl
sp
ml
sp
ml
sp
ml
cl
sm
△200/ND
ml
sm
ml
sm
ml

(5)



B
EXB01
EL. 324.7
sm
sp
sm
ml
sp
ml
sp
ml
cl
sp
ml
cl
ml
sp
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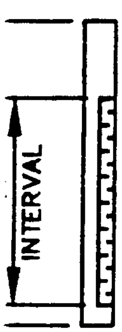
sm
ml
sm
320
260
250
240
230
220
210
200
MWBP-09
(470/ND^b)
MWBP-09B
(500/0)
ND/ND
LEGEND
9/20
HYDROPUNCH GR(
WITH TCE/PCE C(
GROUND WATER T
ml/cl
SILT, SANDY SILT,
sm
SILTY SAND
sp
SAND
sw
COARSE SAND, GF
FILTER PACK INTERVAL
SCREEN INTERVAL
MWBP-09C
(25/0)
WELL N
IN PPE

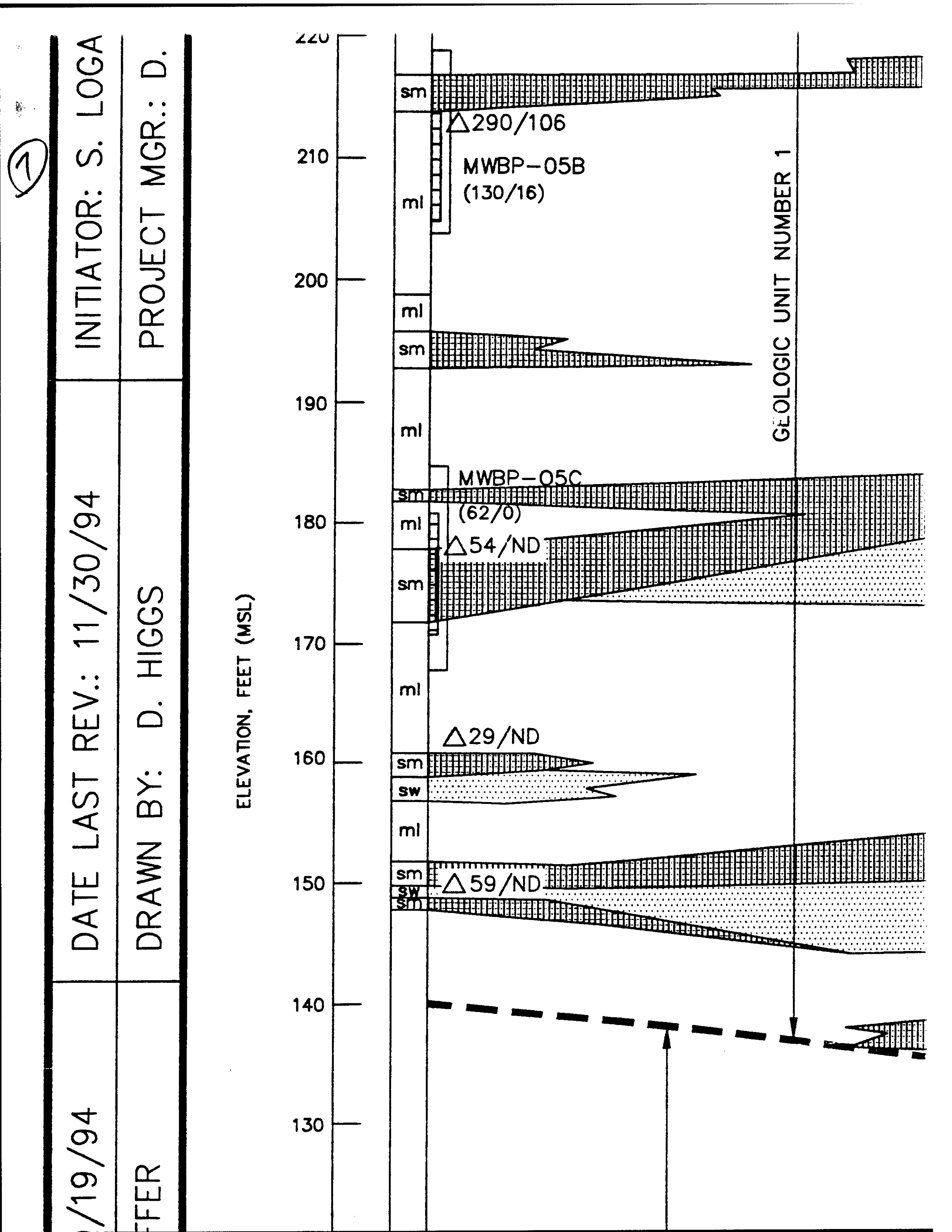
(6)

EGEND

△ 3/20	HYDROPUNCH GROUNDWATER SCREENING SAMPLE LOCATION WITH TCE/PCE CONCENTRATION IN PPB
▼	GROUND WATER TABLE ELEVATION
nl/cl	SILT, SANDY SILT, CLAY
sm	SILTY SAND
sp	SAND
sw	COARSE SAND, GRAVEL



MWBP–09C (25/0) WELL NOMENCLATURE WITH TCE/PCE CONCENTRATION IN PPB



INITIATOR: S. LOGA
PROJECT MGR.: D.
DATE LAST REV.: 11/30/94
DRAWN BY: D. HIGGS
/19/94
FFER
ELEVATION, FEET (MSL)
220
210
200
190
180
170
160
150
140
130
sm
ml
ml
sm
ml
sm
ml
sm
ml
sm
sw
ml
sm
sw
sm
290/106
MWBP-05B
(130/16)
MWBP-05C
(62/0)
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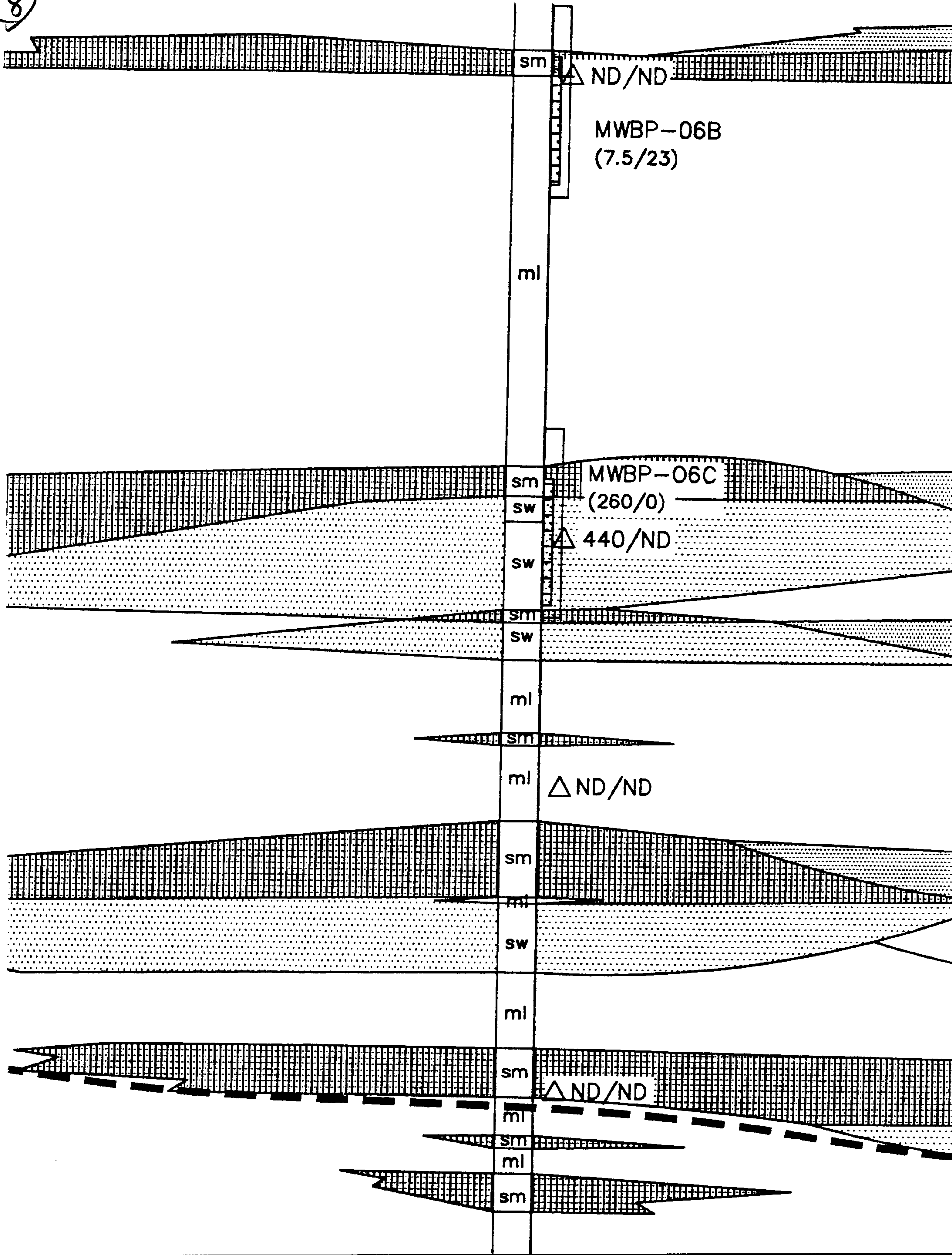
29/ND
59/ND
GEOLOGIC UNIT NUMBER 1

(8)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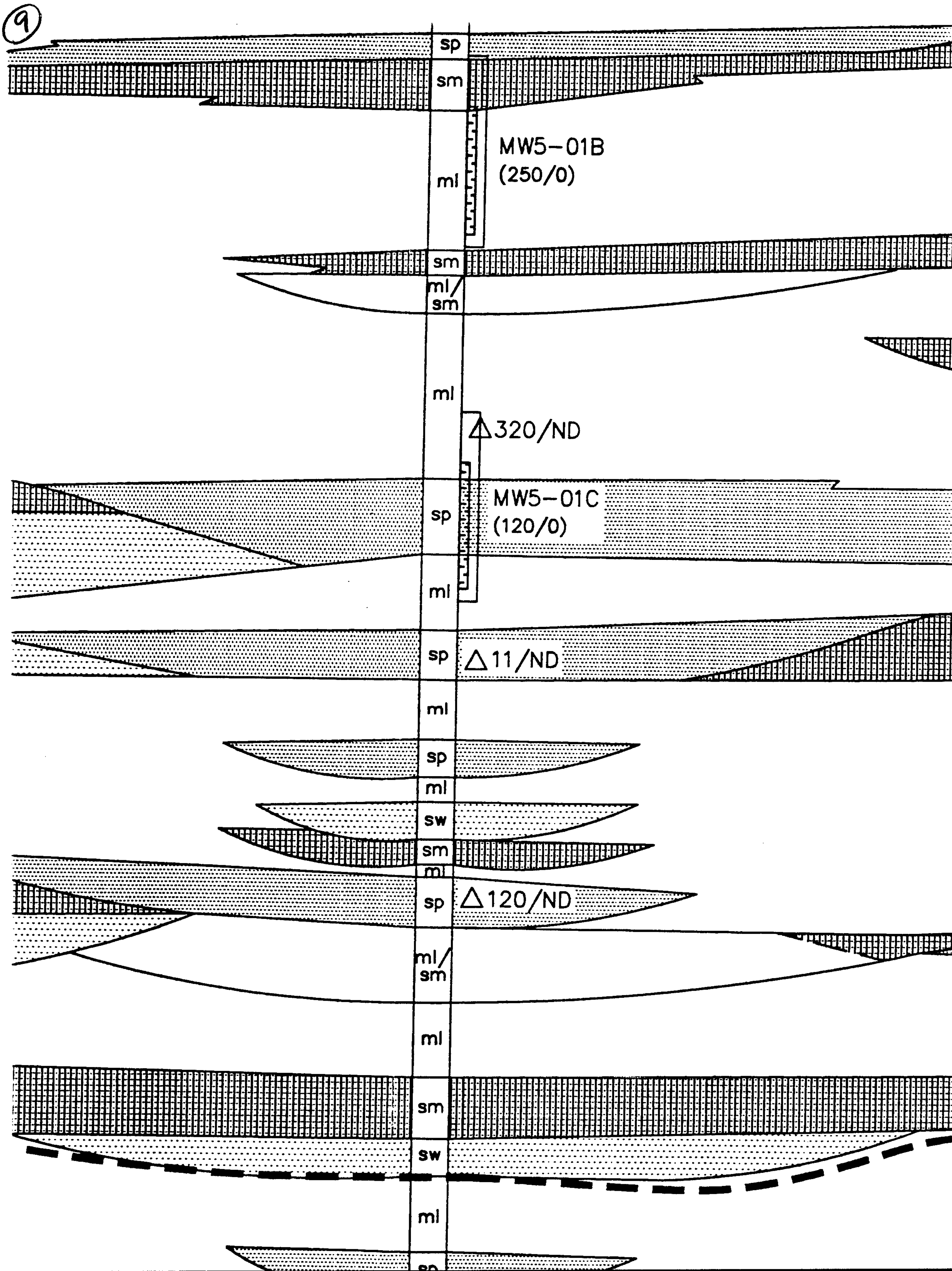
ND/ND
ml
sm
ml
sm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sp
sm
MW5-01B
(250/0)
ml
sm
ml/
sm
ml
320/ND
MW5-01C
(120/0)
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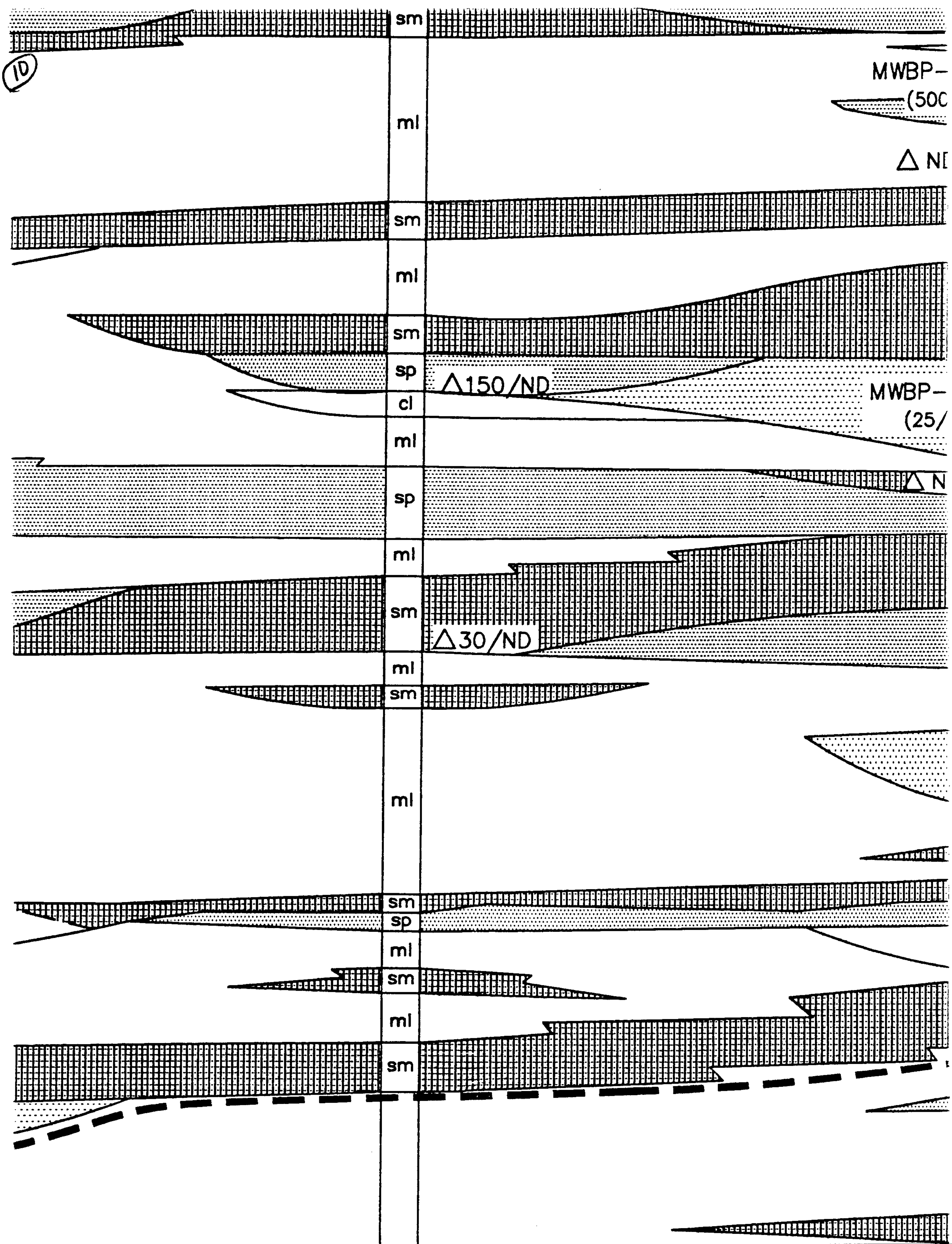
sw
ml
sp


10
sm
MWBP-
(500
ml
△ NI
sm
ml
sm
sp
△150/ND
MWBP-
(25/
cl
ml
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sp
ml
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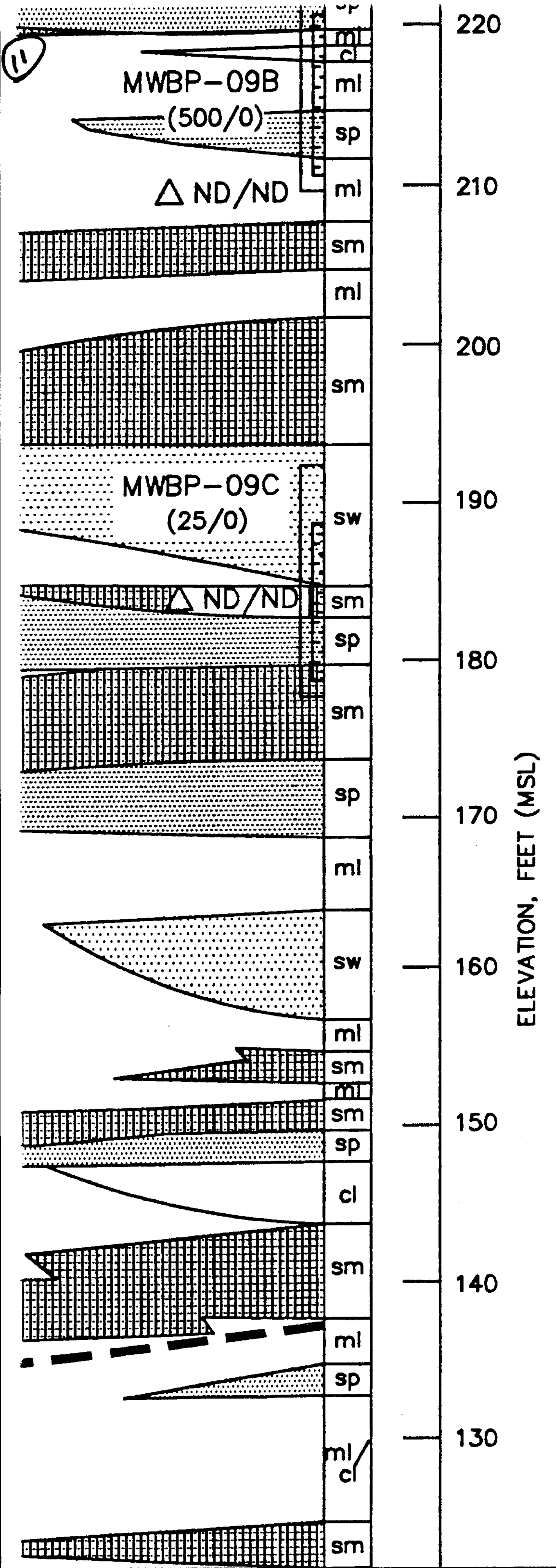
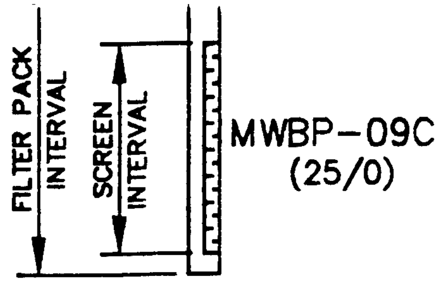
ml
sm





WELL NOMENCLATURE
IN PPB

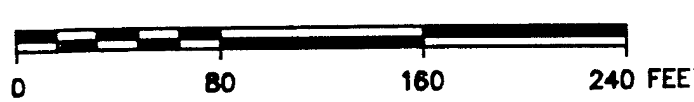
NOTES:

△ HYDROPUNCH SAMPLES COLLECT

a AVERAGE CONCENTRATION OF 6
11/90 TO 4/93

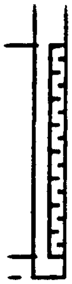
b AVERAGE CONCENTRATION OF 3
10/92 TO 4/93

HORIZONTAL SCALE



VERTICAL SCALE

12



MWBP–09C (25/0) WELL NOMENCLATURE WITH TCE/PCE CONCENTRATION IN PPB

S:

HYDROPUNCH SAMPLES COLLECTED 10/93

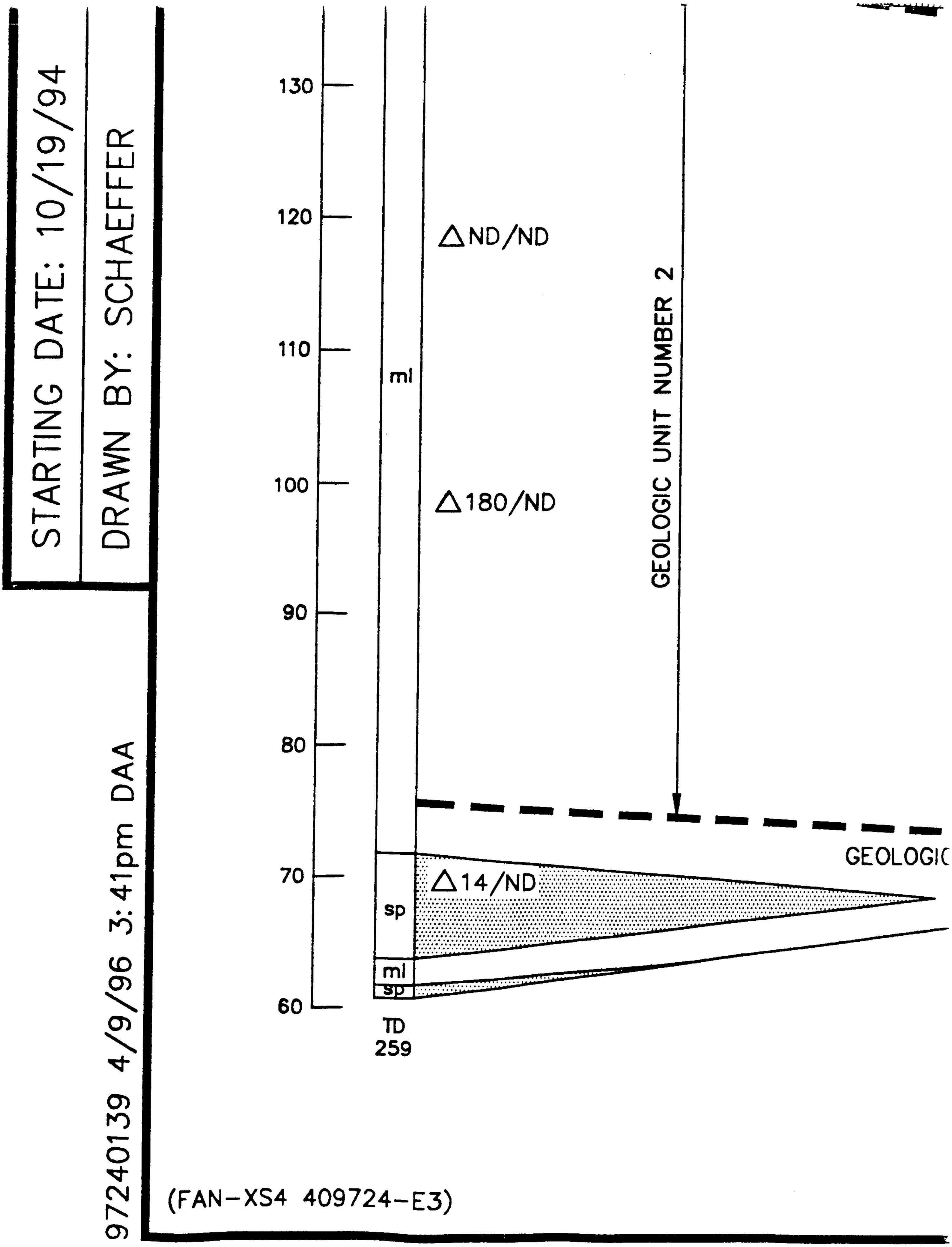
AVERAGE CONCENTRATION OF 6 SAMPLES COLLECTED FROM 11/90 TO 4/93

AVERAGE CONCENTRATION OF 3 SAMPLES COLLECTED FROM 10/92 TO 4/93

HORIZONTAL SCALE

80 160 240 FEET

13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110
100
90
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60
ml
sp
ml
sp
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△ND/ND
△180/ND
△14/ND
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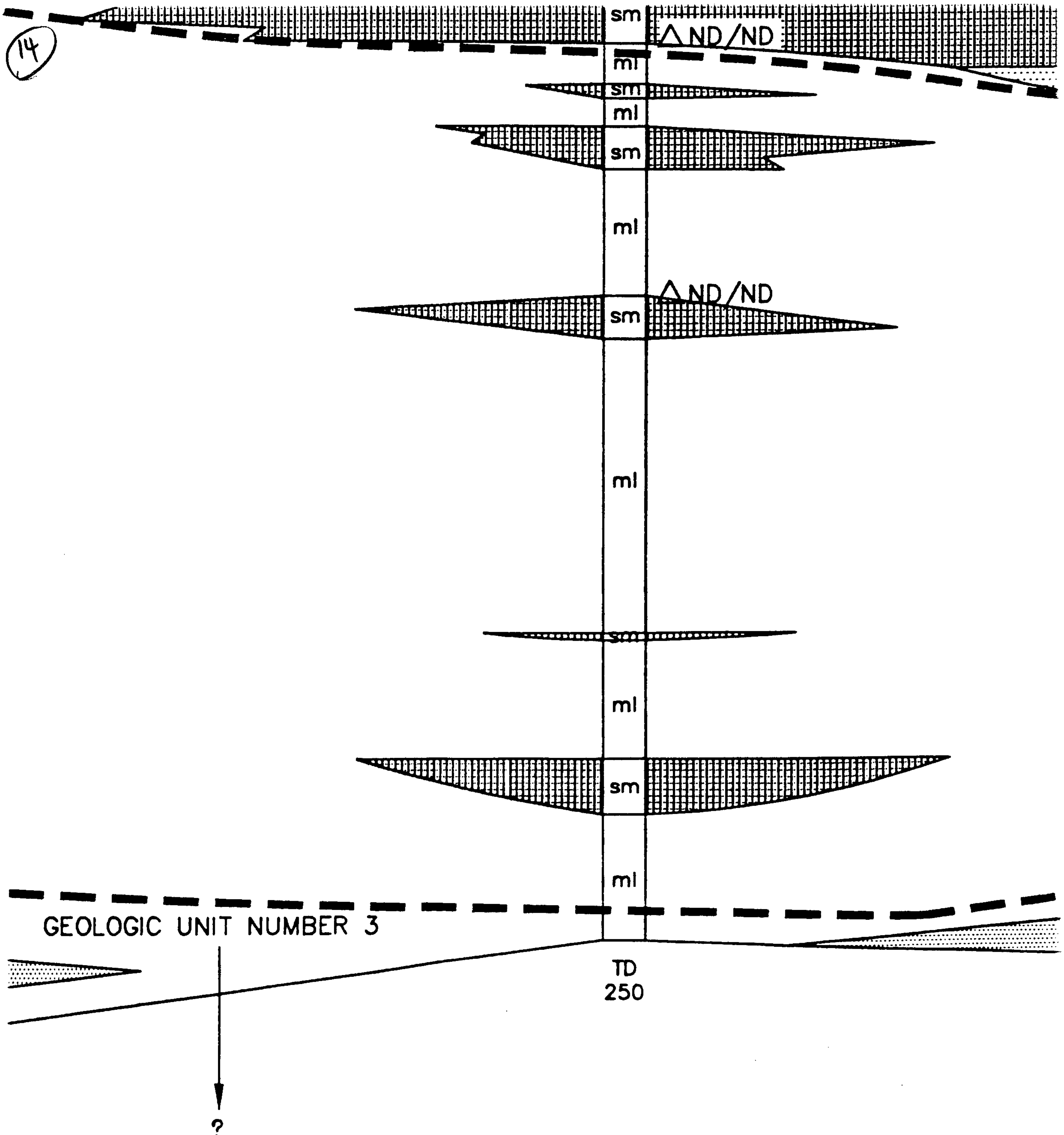
GEOLOGIC
97240139 4/9/96 3:41pm DAA
(FAN-XS4 409724-E3)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ΔND/ND
ml
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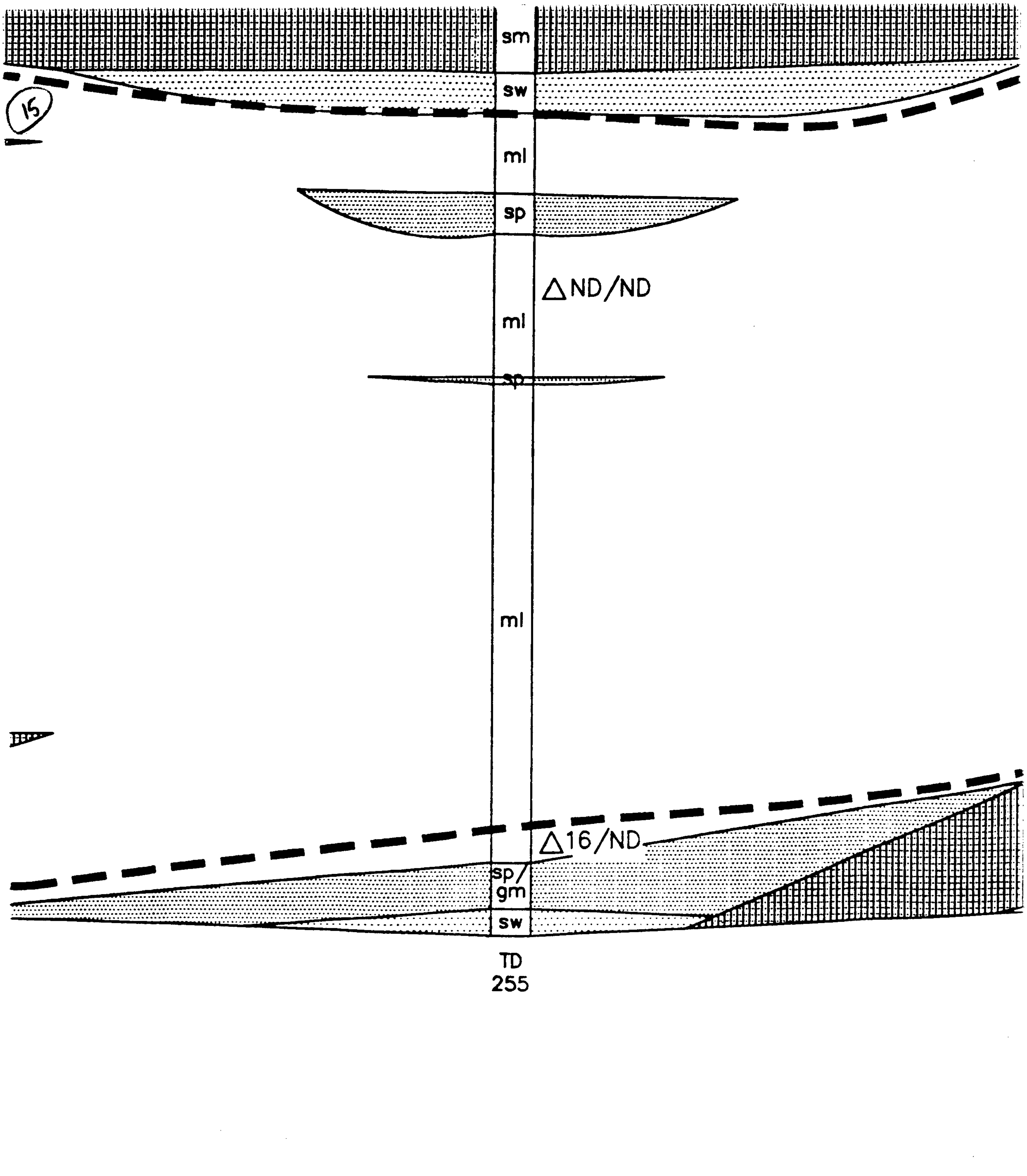
ml
sm
ml
ΔND/ND
sm
ml
sm
ml
sm
ml
GEOLOGIC UNIT NUMBER 3
TD
250
?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sw
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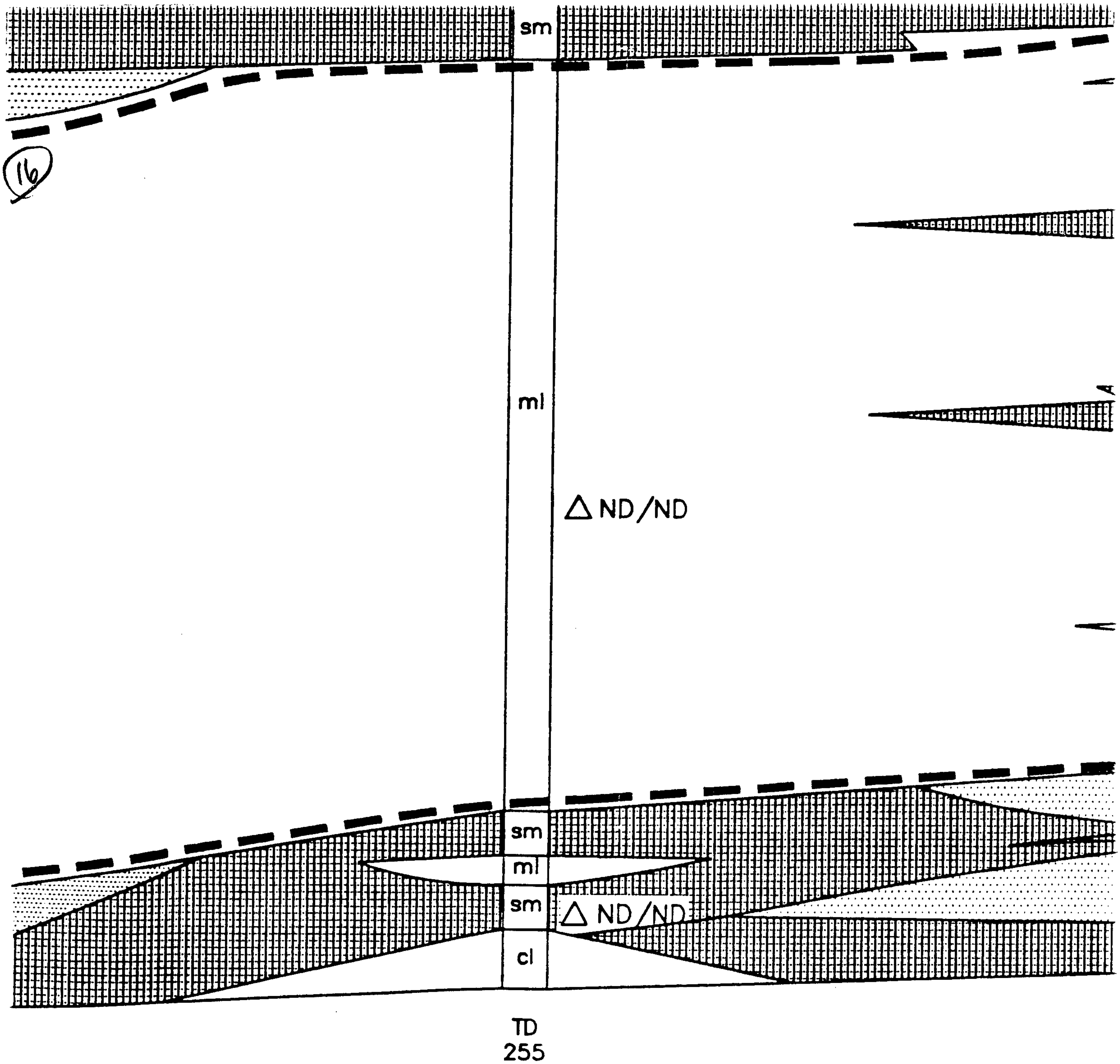

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ml
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△ ND/ND
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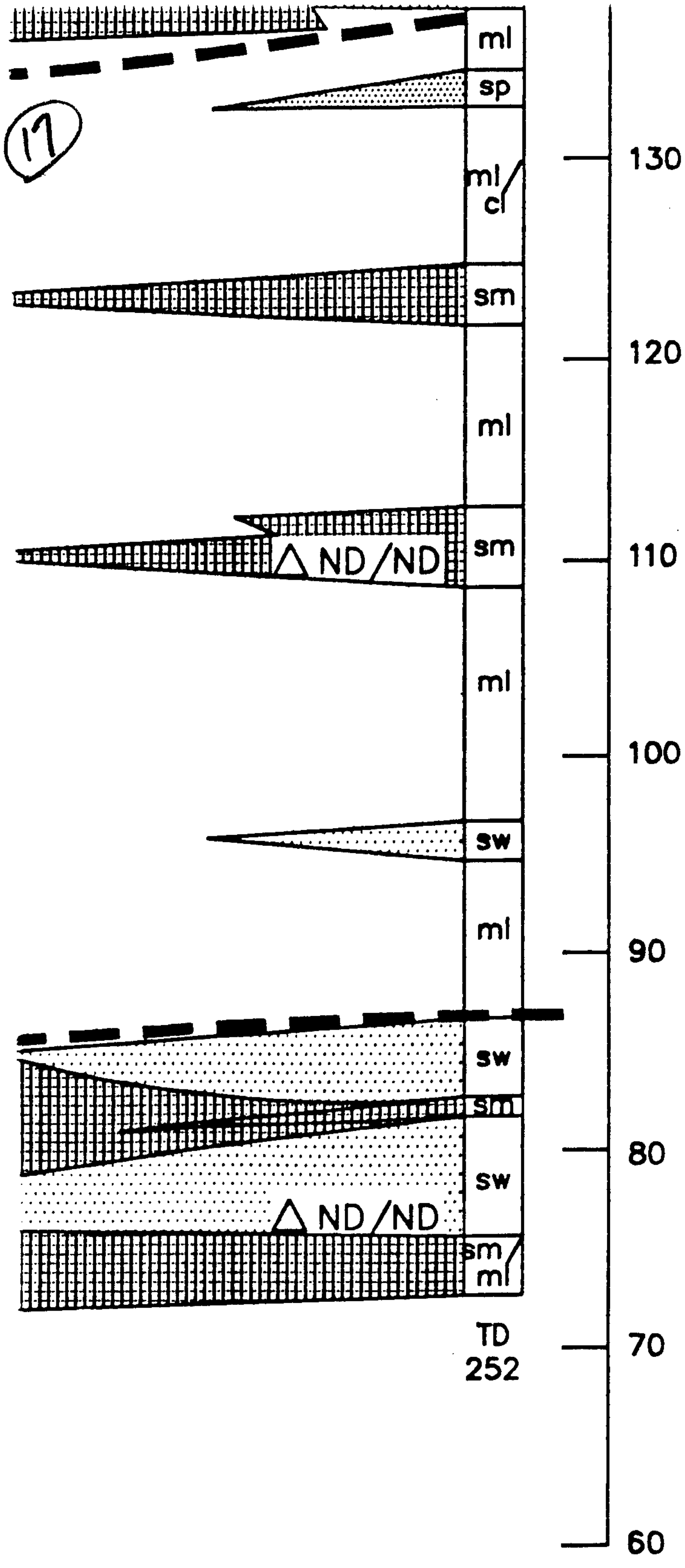
17



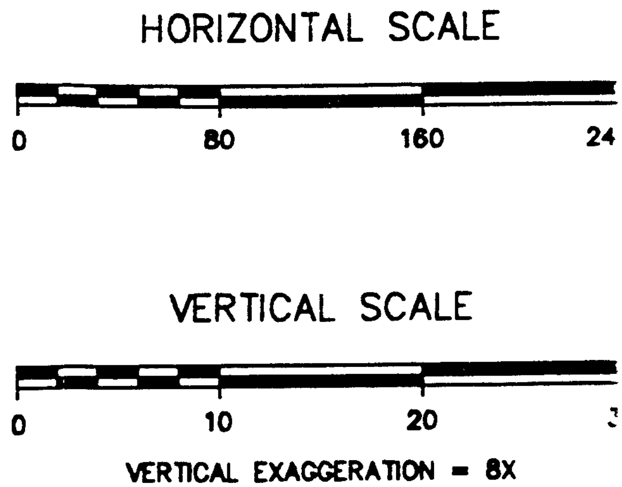


FIGURE 5-2

DEEP AQUIFER GEOLOGIC CROS MONITORING WE CHEMICAL DATA

CALIFORNIA AIR NATIO
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

18

HORIZONTAL SCALE

0 80 160 240 FEET

VERTICAL SCALE

0 10 20 30 FEET

VERTICAL EXAGGERATION = 8X

;URE 5-2

EP AQUIFER INVESTIGATION
OLOGIC CROSS SECTION WITH
)NITORING WELL AND
EMICAL DATA

IFORNIA AIR NATIONAL GUARD
'SNO AIR TERMINAL
'SNO, CALIFORNIA

INTERNATIONAL
TECHNOLOGY
CORPORATION

a fifth (EXB-04) projected 400 feet from the southwest onto the cross section (see Figure 4-6). Boring logs are included as Appendix F.

The geologic section below the water table has three major lithologic zones that represent changing depositional environments. Sequences of glacio-fluvial and possibly lacustrine origin indicate repeated depositional patterns, recording the migration of stream channels across the broad, glacial, Fresno alluvial fan. The three major lithologic zones below the water table are identified as Geologic Units No. 1 through 3.

5.3.1.1 Geologic Unit No. 1 (Upper Unit)

Geologic Unit No. 1 includes the upper 100 to 110 feet of the saturated zone, from approximately 240 to 140 feet msl elevation. The lithology consists of alternating silts and sands, with layers of intermixed silt and sand. Clay fractions are present in most of the finer grained lithologies, but few distinct clay layers are observed. Densities vary from very soft to very hard, with the majority of this unit having densities of soft to slightly hard. The majority of the unit is very moist to wet, but some intervals are slightly moist to dry. A slight southwest component of dip is observed on many of the laterally extensive sand units. This is consistent with observations of Cehrs, et al. (1979) and is reasonable given the alluvial fan origin of the units.

Geologic Unit No. 1 is a repetitive sequence of thick silt to sandy silt layers separated by thinner sand units. The silt units are as thick as 30 feet and frequently contain isolated sand lenses. The sand units, which range from silty sand to well sorted sand, occur as continuous layers that extend across the entire section (Figure 5-2). Sand unit thicknesses are as great as 15 feet, with most layers between 5 and 10 feet thick. The first sand-silt sequence seen in Figure 5-2 between 250 and 220 feet msl roughly corresponds in depth to Cehrs (1979) Turlock Lake Formation (see Section 3.6). The sedimentary sequence suggests a glacial alluvial fan origin similar to that suggested by Cehrs. A sand lens (240 to 255 feet msl) and an underlying thick silt layer observed at the southwest end of the cross section in EXB-04 and EXB-05 (220 to 240 feet msl) suggest that additional depositional processes were at work as well. The 20-foot-thick silt found at the southwest end of the section between 240 and 220 feet msl (Figure 5-2) and the thick accumulations of sand at the northeast half of the profile can be attributed to alluvial fan overbank and floodplain deposition. The overlying sand layers (240 to 250 feet msl) have a greater lateral extent and homogeneity than would be expected from the braided to meandering stream environment. The sequence could reasonably be attributed solely to alluvial fan deposition, but the thick accumulation of silt to the

southwest and the continuity of the sand layers suggests deposition in a shallow lake (lacustrine) environment. An alternate explanation for the lithology is lacustrine deposition with winnowing of sands at the upper surface to form the sand layer. The superimposition of stream channel deposition over periods of time could explain the more lens-shaped features in the northeast part of the section.

The depositional pattern repeats itself over the 220 to 185 feet msl interval below with an even a thicker silty layer and less evidence of stream channel action (sand deposition). Below 185 feet msl, the pattern is repeated two more times, although the layered configuration of the sand bodies suggests a greater component of stream channel activity. The thick accumulations of silty material below each major sand unit suggests periods of rapid deposition under shallow lake conditions. The pattern is disrupted below 140 feet msl with the introduction of a thick silt layer that apparently represents an earlier period of deposition with radically different rates of sediment accumulation than seen in the upper unit.

5.3.1.2 Geologic Unit No. 2

The second lithology, a thick and dense silt, is found below 140 and above 80 feet msl (Figure 5-2). This unit is a thick accumulation of nearly homogeneous silt that represents either a very rapid accumulation of sediments or a lengthy period of stable depositional conditions. The unit is predominantly silt, with a few thin, laterally restricted sand layers. The unit is very homogeneous, very hard, and exhibited little water content. The nearly indurated nature of the unit suggests a much older age than Unit No. 1. The rate of sediment accumulation was probably high and stream channel activity was probably not present during deposition. The depositional environment appears to be a shallow to moderately deep lake.

5.3.1.3 Geologic Unit No. 3

The third lithology is encountered near the bottom of the exploratory borings, below 90 feet msl, and includes mixed silt and sand similar to Unit No. 1, with the inclusion of some gravels. The thickness of this third unit is undetermined from this investigation. The upper surface of the unit appears to express a southwest dip that is greater than that observed in the other units. The lithologies present in this layer suggest that it was deposited in conditions similar to Unit No. 1.

5.3.2 Hydrogeologic Interpretation

The hydrologic regime at the site influences the transport of contaminants laterally and vertically. The definition of the deep aquifer hydrology requires the integration of geologic, hydrologic, and contaminant distribution. Exploratory boring and groundwater contaminant screening data were used to define aquifers and aquitards at depths below the water table. Monitoring wells installed to depths of approximately 150 feet bgs (170 feet msl) were installed based on the available chemical screening data. The interpreted hydrologic regime and well installations are illustrated on Figure 5-3. A larger view of the deep well screened intervals and hydrogeology is presented in Figure 4-7. A description of the aquifer and aquitard units and the rationale for this assignment is outlined in the following paragraphs.

The aquifer and aquitard units were designated based on a detailed evaluation of lithology, moisture content, and hardness. Sand and silt beds were grouped according to probable hydraulic communication. Sediments that were moist to wet and soft to slightly stiff were interpreted to be aquifer material. This included much fine-grained material that may be considered aquitard material in other classical interpretations. Vertical hydrologic connection is thought to exist through the fine-grained sediments present in the aquifer section, allowing for partial interconnection of water-bearing units. Aquifer boundaries, in some cases, do not correspond to lithologic boundaries. Aquitards restrict vertical groundwater flow and act as barriers to the movement of contaminants. Aquitards, characterized as moist to dry, stiff to very hard sediments were present throughout the section in continuous to somewhat discontinuous layers. Geotechnical sample results, which include moisture content and vertical conductivity, are included in Appendix G.

Aquitards are formed by well-compacted (hard and dry) units, normally finer-grained silt lithologies. In some cases, coarse-grained material was included in the aquitards because of the observed characteristics of the material. Depositional environment, age, and compaction appear to be factors influencing the creation of aquitards. Cementation is a factor in some units, but compaction appears to be the more important in aquitard formation.

The following subsections present the rationale and supporting information on how the saturated geologic materials were divided into different aquifer units, based on the previous discussion.

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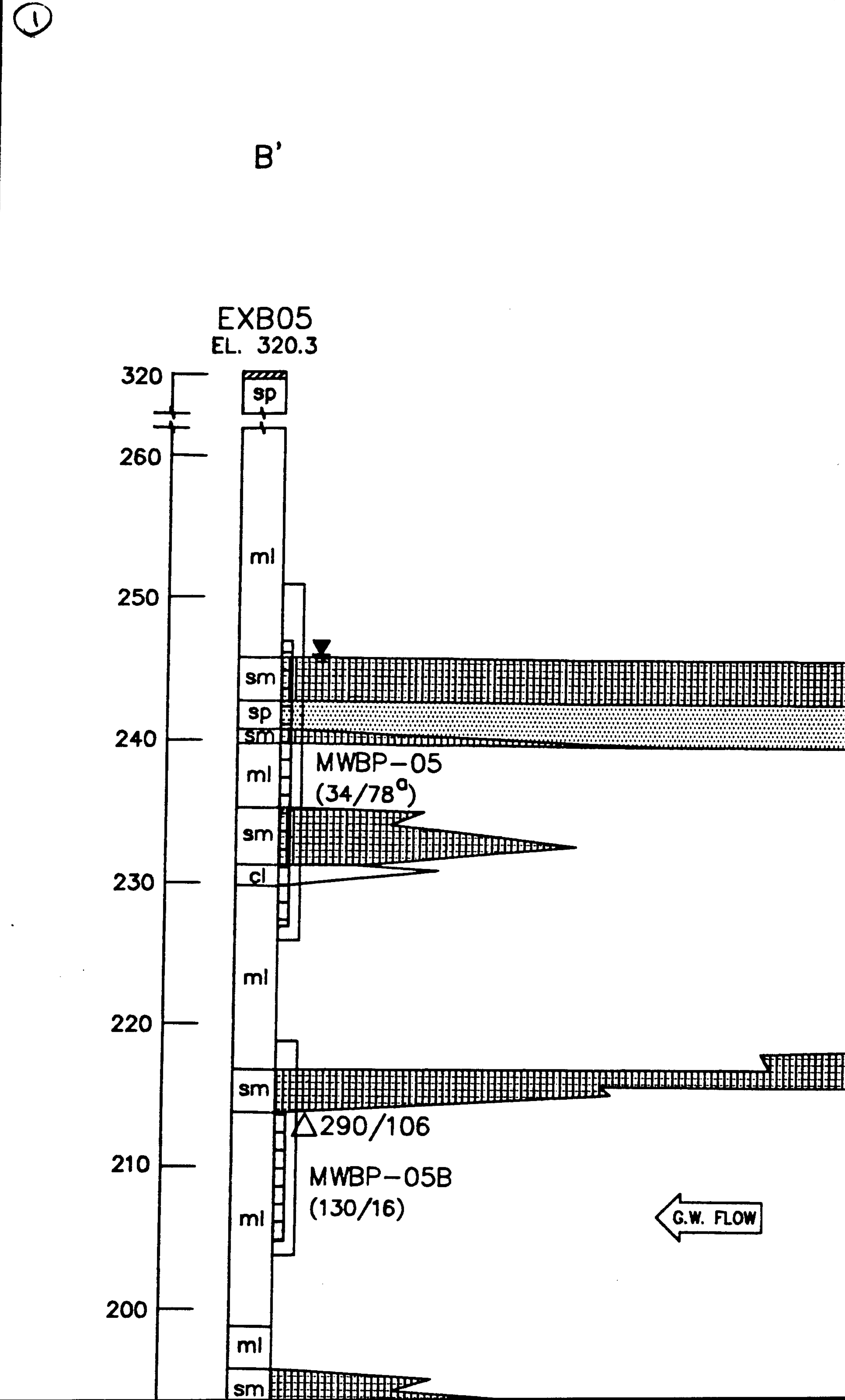
DRAWING NO.: 409724-D-140

PROJECT MGR.: D. BURTON

PROJECT NO.: 409724



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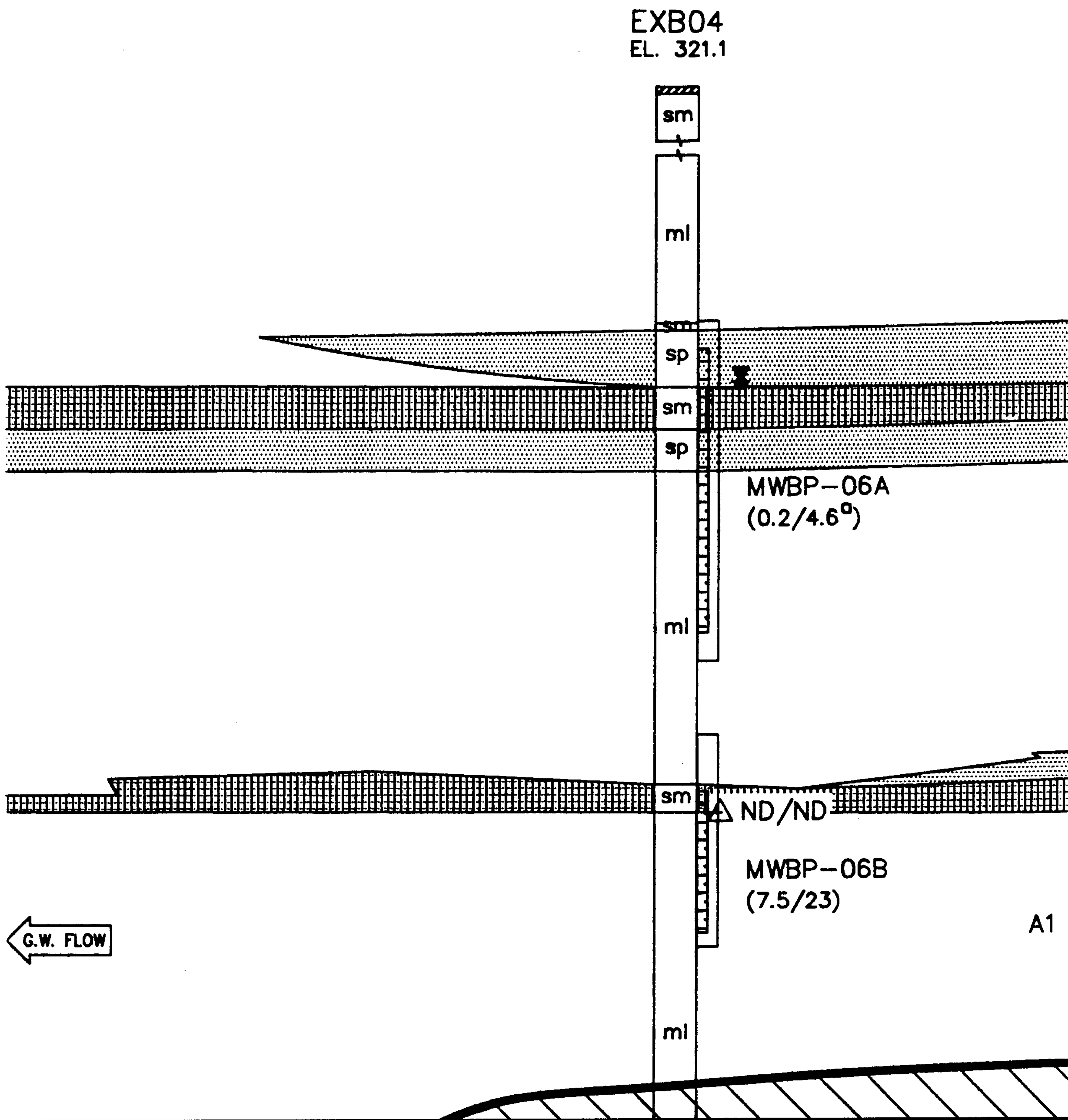
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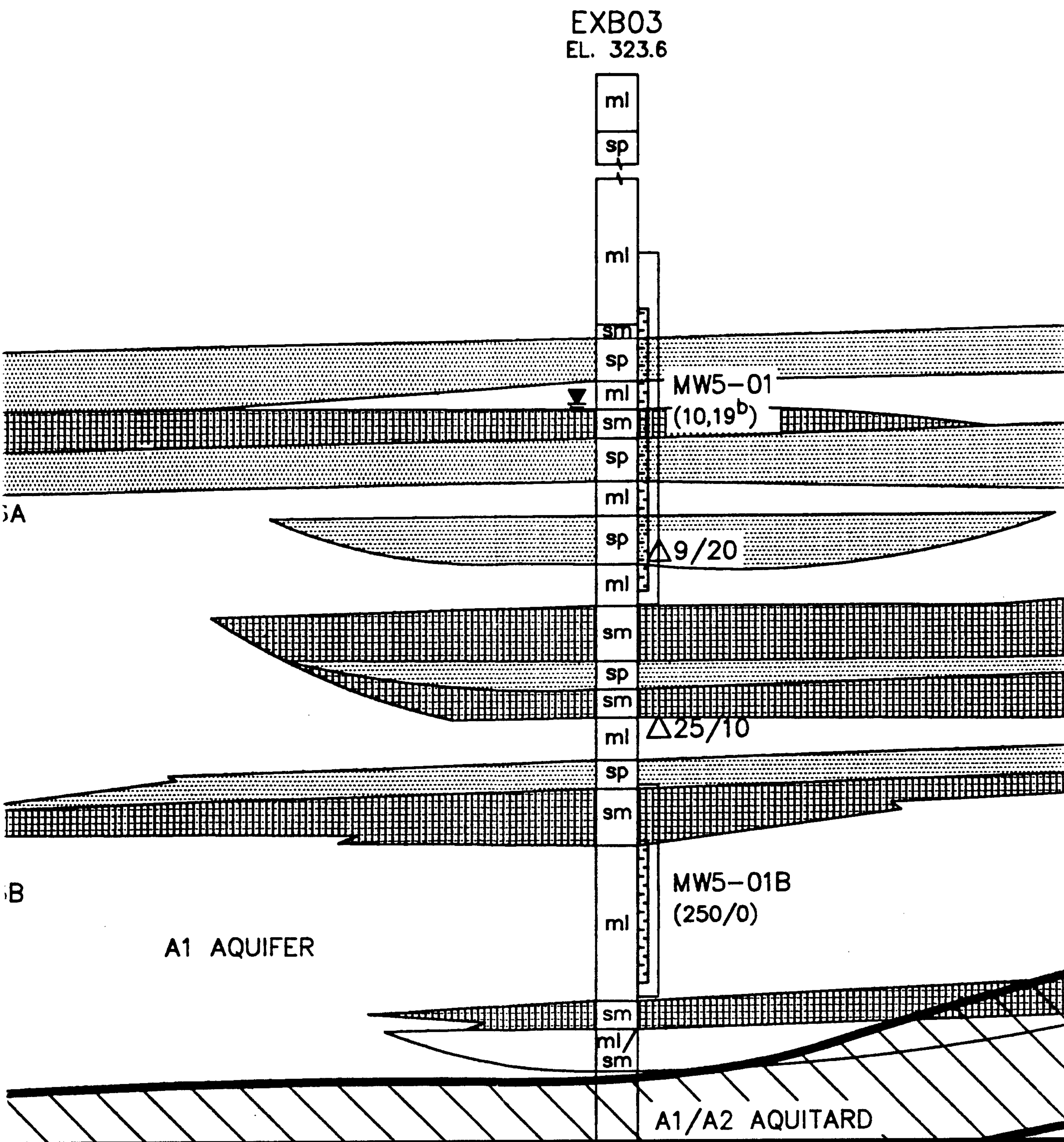
EL. 321.1
sm
ml
sm
sp
sm
sp
MWBP-06A
(0.2/4.6[a])
ml
sm
ND/ND
MWBP-06B
(7.5/23)
A1
G.W. FLOW
ml

(3)


EXB03
EL. 323.6
ml
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ml
sm
sp
MW5-01
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sm
(10,19b)
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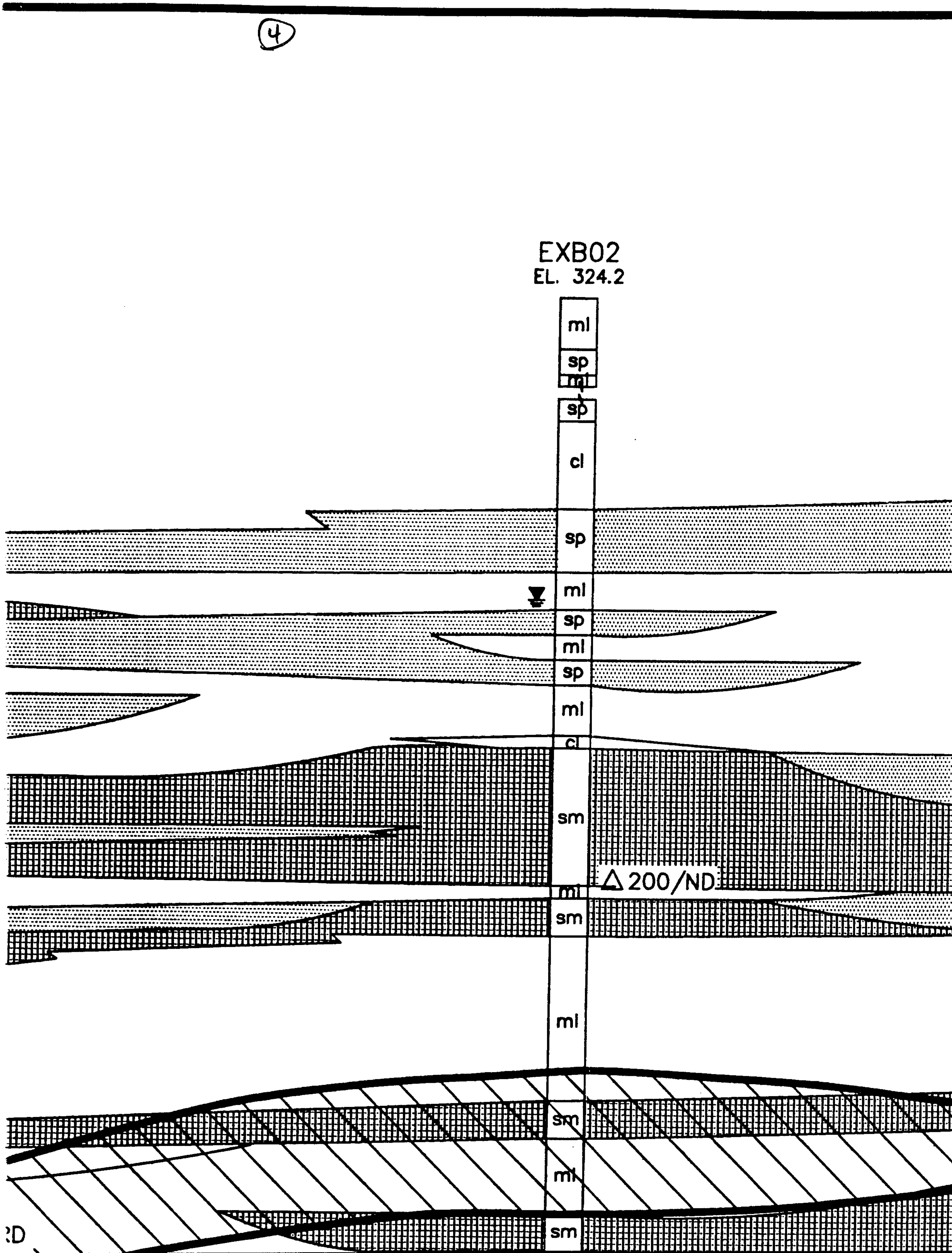
A
ml
sp
9/20
ml
sm
sp
sm
25/10
ml
sp
sm
B
MW5-01B
(250/0)
ml
A1 AQUIFER
sm
ml/sm
A1/A2 AQUITARD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EXB02
EL. 324.2
ml
sp
ml
sp
cl
sp
ml
sp
ml
sp
ml
cl
sm
△200/ND
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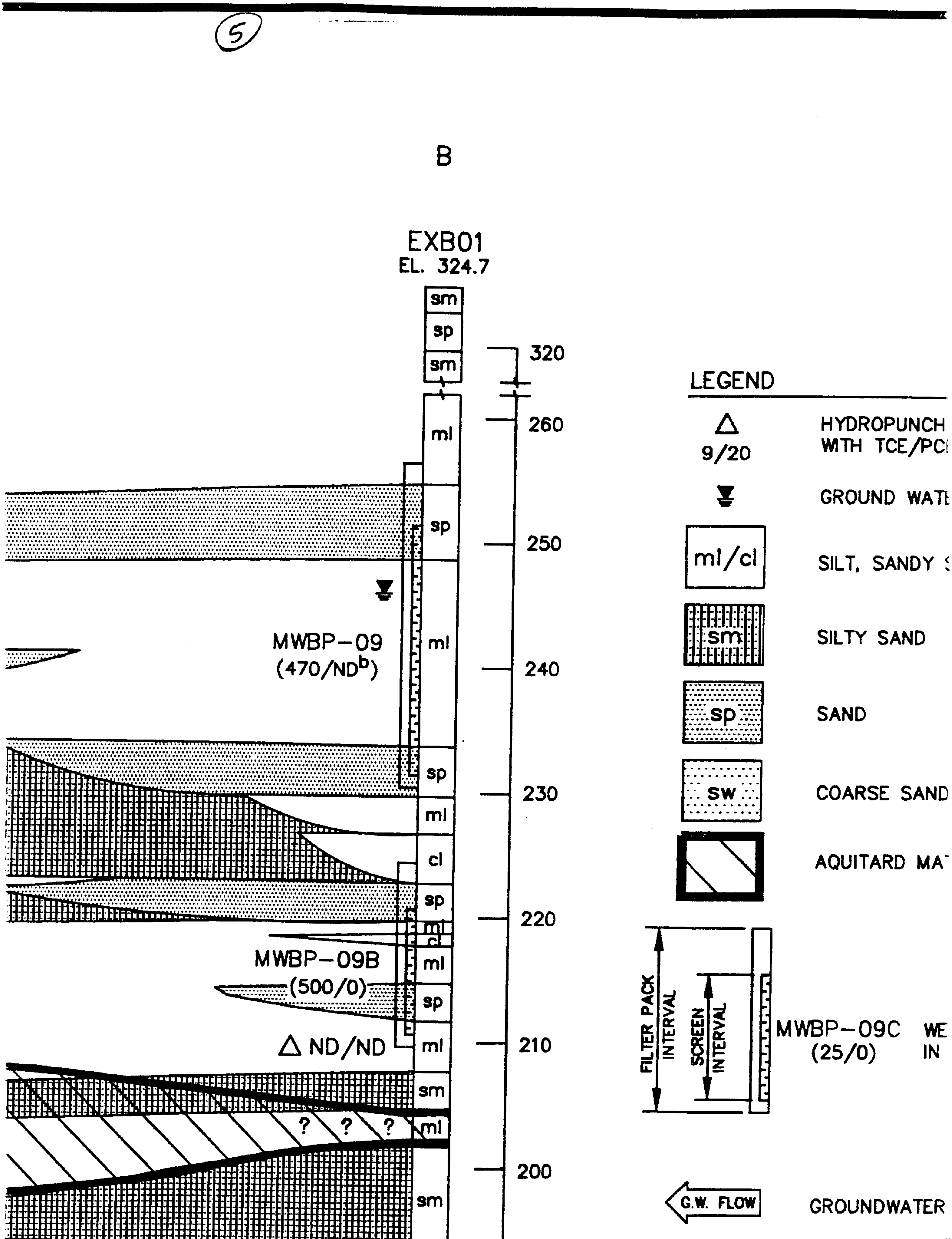
ml
sm
ml
sm
RD



5
B
EXB01
EL. 324.7
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sp
sm
ml
sp
ml
sp
ml
cl
sp
ml
cl
ml
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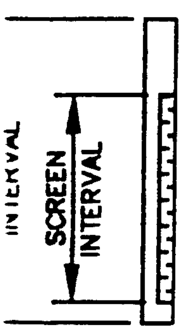
ml
sm
ml
sm
320
260
250
240
230
220
210
200
MWBP-09
(470/ND^b)
MWBP-09B
(500/0)
△ ND/ND
? ? ?
LEGEND
△
9/20
HYDROPUNCH
WITH TCE/PC
GROUND WAT
ml/cl
SILT, SANDY
sm
SILTY SAND
sp
SAND
sw
COARSE SAND
AQUITARD MA
FILTER PACK INTERVAL
SCREEN INTERVAL
MWBP-09C
(25/0)
WE
IN
G.W. FLOW
GROUNDWATER

6

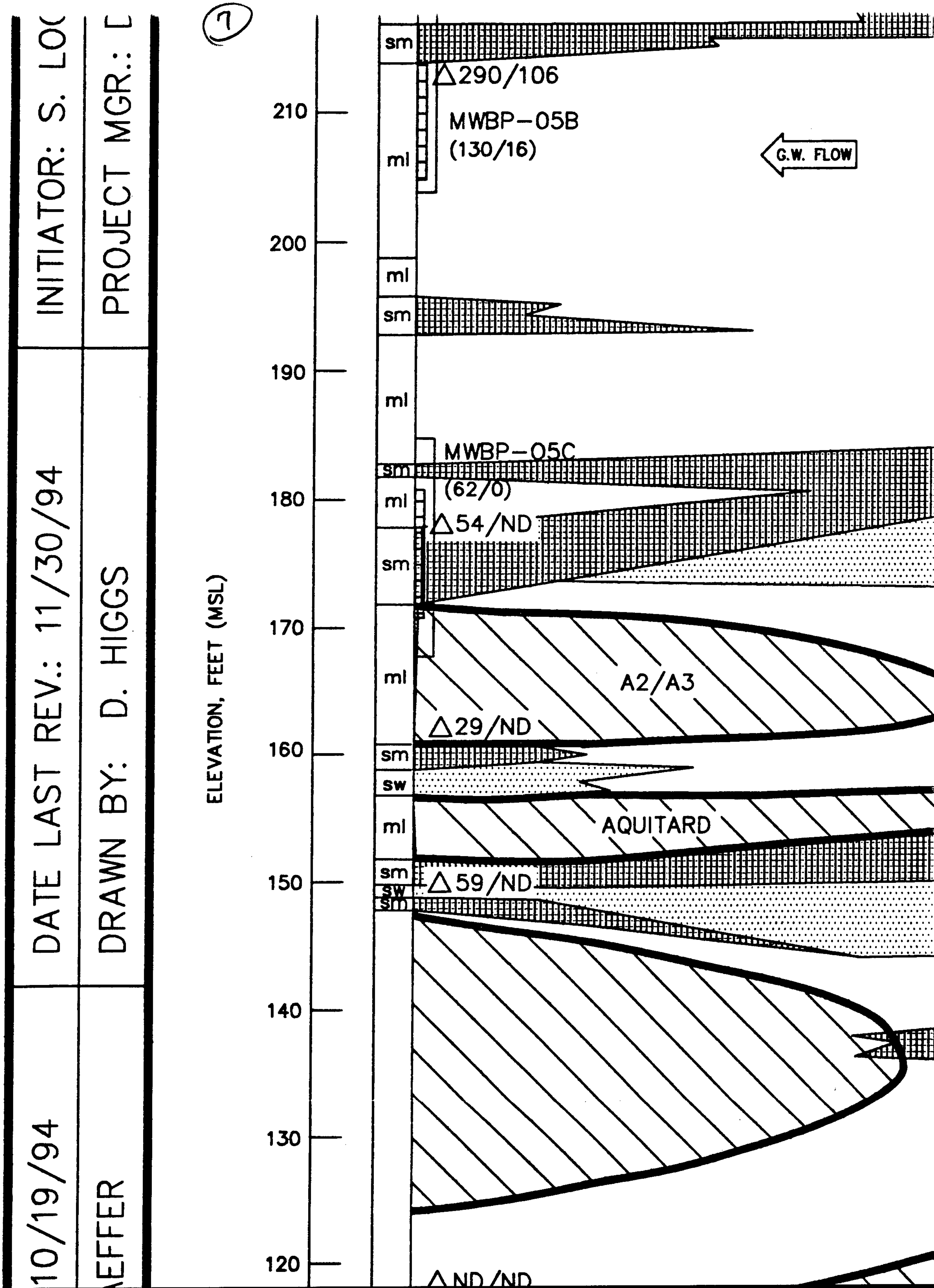
LEGEND

Symbol	Description
△ 9/20	HYDROPUNCH GROUNDWATER SCREENING SAMPLE LOCATION WITH TCE/PCE CONCENTRATION IN PPB
▼	GROUND WATER TABLE ELEVATION
ml/cl	SILT, SANDY SILT, CLAY
sm	SILTY SAND
sp	SAND
sw	COARSE SAND, GRAVEL
	AQUITARD MATERIAL

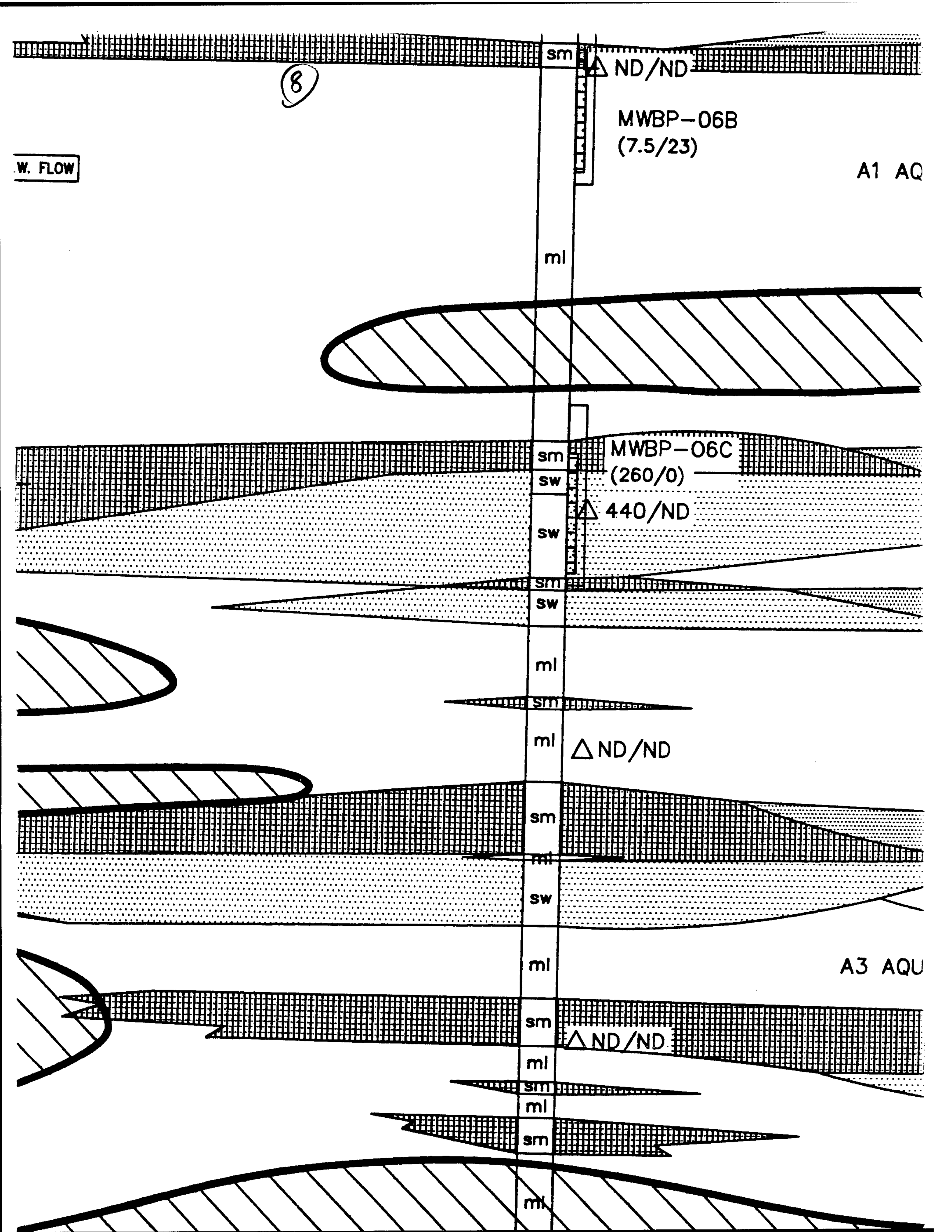


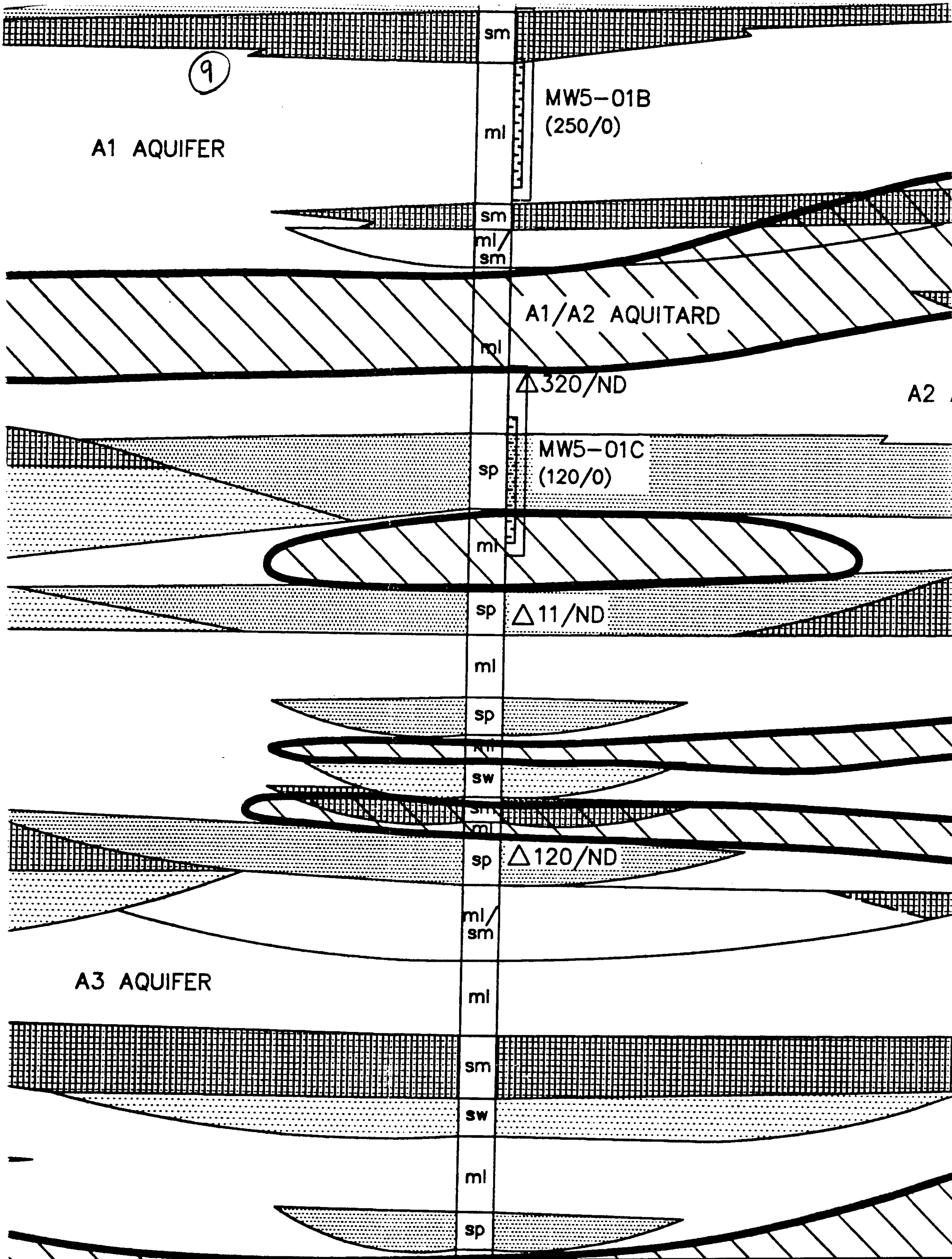
MWBP–09C (25/0) WELL NOMENCLATURE WITH TCE/PCE CONCENTRATION IN PPB

G.W. FLOW — GROUNDWATER FLOW DIRECTION



INITIATOR: S. LO
PROJECT MGR.: D
DATE LAST REV.: 11/30/94
DRAWN BY: D. HIGGS
10/19/94
EFFER
7
ELEVATION, FEET (MSL)
210
200
190
180
170
160
150
140
130
120
sm
ml
ml
sm
ml
sm
ml
sm
ml
sm
sw
ml
sm
sw
sm
290/106
MWBP-05B
(130/16)
G.W. FLOW
MWBP-05C
(62/0)
54/ND
A2/A3
29/ND
AQUITARD
59/ND
ND/ND


8
.W. FLOW
sm
ND/ND
MWBP-06B
(7.5/23)
A1 AQ
ml
sm
MWBP-06C
(260/0)
sw
440/ND
sw
sm
sw
ml
sm
ml
ND/ND
sm
ml
sw
ml
A3 AQU
sm
ND/ND
ml
sm
ml
sm
ml



sm
9
MW5-01B
(250/0)
ml
A1 AQUIFER
sm
ml/
sm
A1/A2 AQUITARD
ml
△320/ND
A2
MW5-01C
(120/0)
sp
ml
sp
△11/ND
ml
sp
ml
sw
sm
ml
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sm
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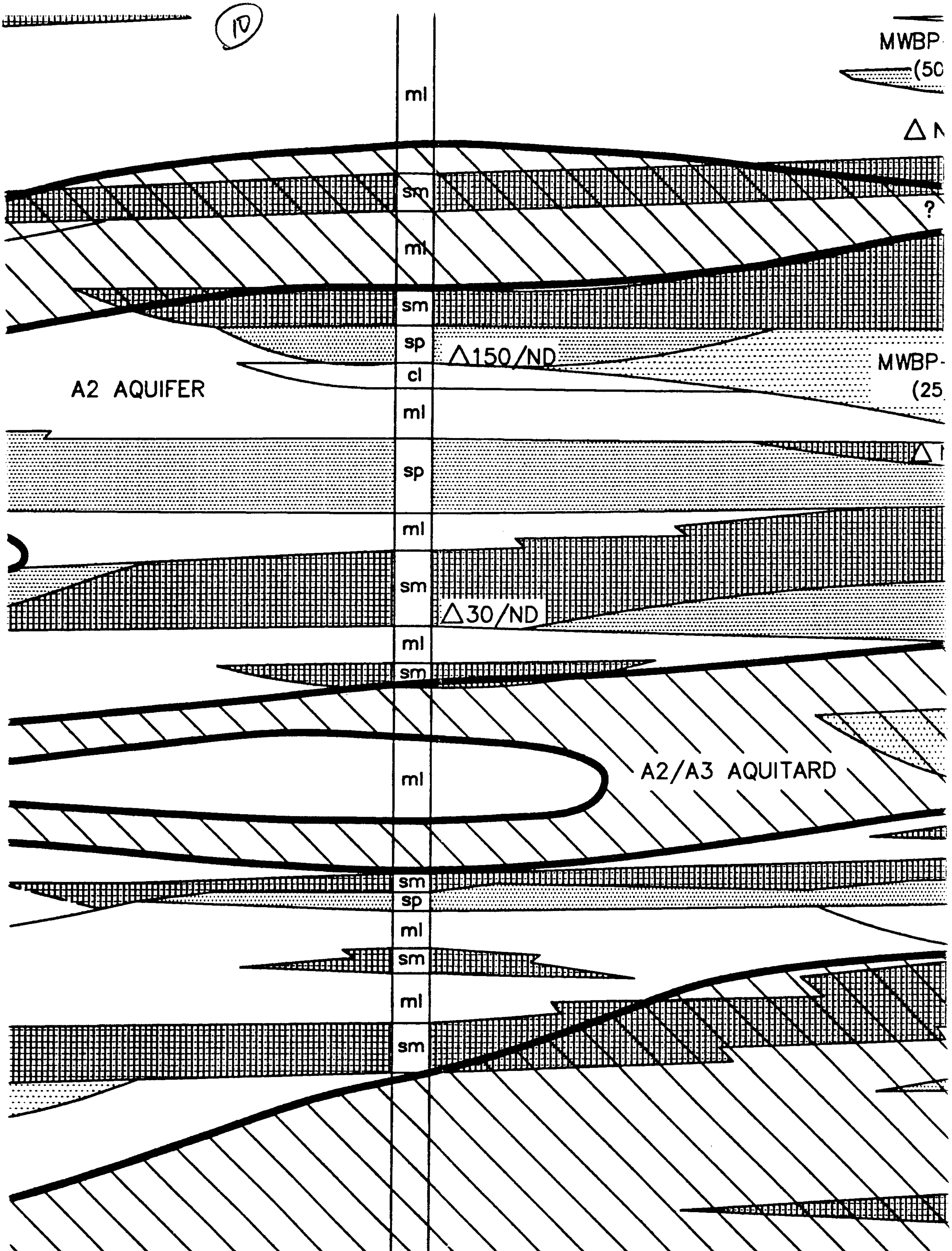
ml
sm
sw
ml
sp



10
MWBP-
(50
ml
sm
?
ml
sm
sp
△150/ND
MWBP-
(25
cl
A2 AQUIFER
ml
sp
ml
sm
△30/ND
ml
sm
ml
A2/A3 AQUITARD
sm
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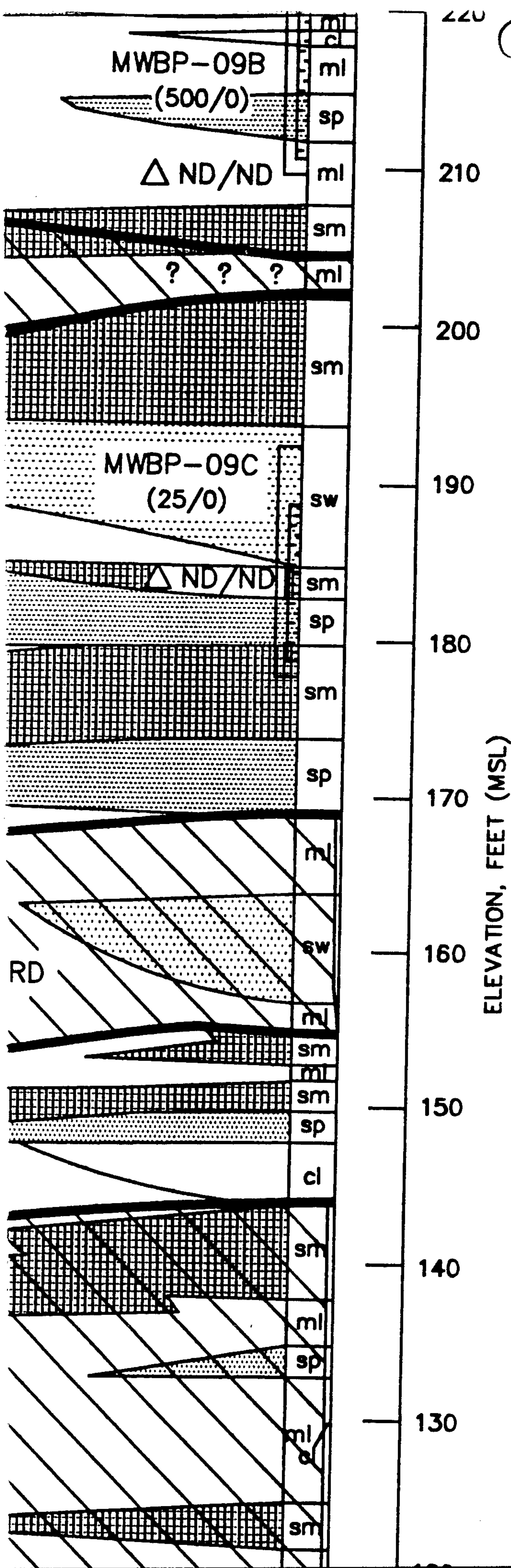
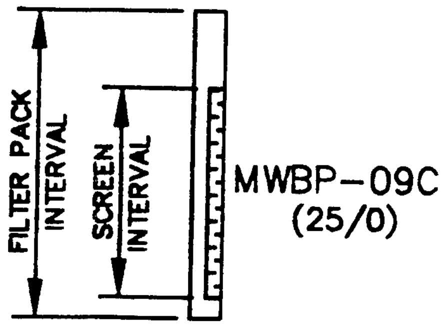
ml
sm
ml
sm





WELL NOMENCLATUR
IN PPB

G.W. FLOW — GROUNDWATER FLOW DIRECTION

NOTES:

△ HYDROPUNCH SAMPLES COLLECTI

a AVERAGE CONCENTRATION OF 6
11/90 TO 4/93

b AVERAGE CONCENTRATION OF 3
10/92 TO 4/93

HORIZONTAL SCALE

0 80 160 240 FEET

VERTICAL SCALE

(12)

INTERVAL

MWBP–09C (25/0) WELL NOMENCLATURE WITH TCE/PCE CONCENTRATION IN PPB

FLOW GROUNDWATER FLOW DIRECTION

TES:

HYDROPUNCH SAMPLES COLLECTED 10/93

AVERAGE CONCENTRATION OF 6 SAMPLES COLLECTED FROM 11/90 TO 4/93

AVERAGE CONCENTRATION OF 3 SAMPLES COLLECTED FROM 10/92 TO 4/93

HORIZONTAL SCALE

80 160 240 FEET

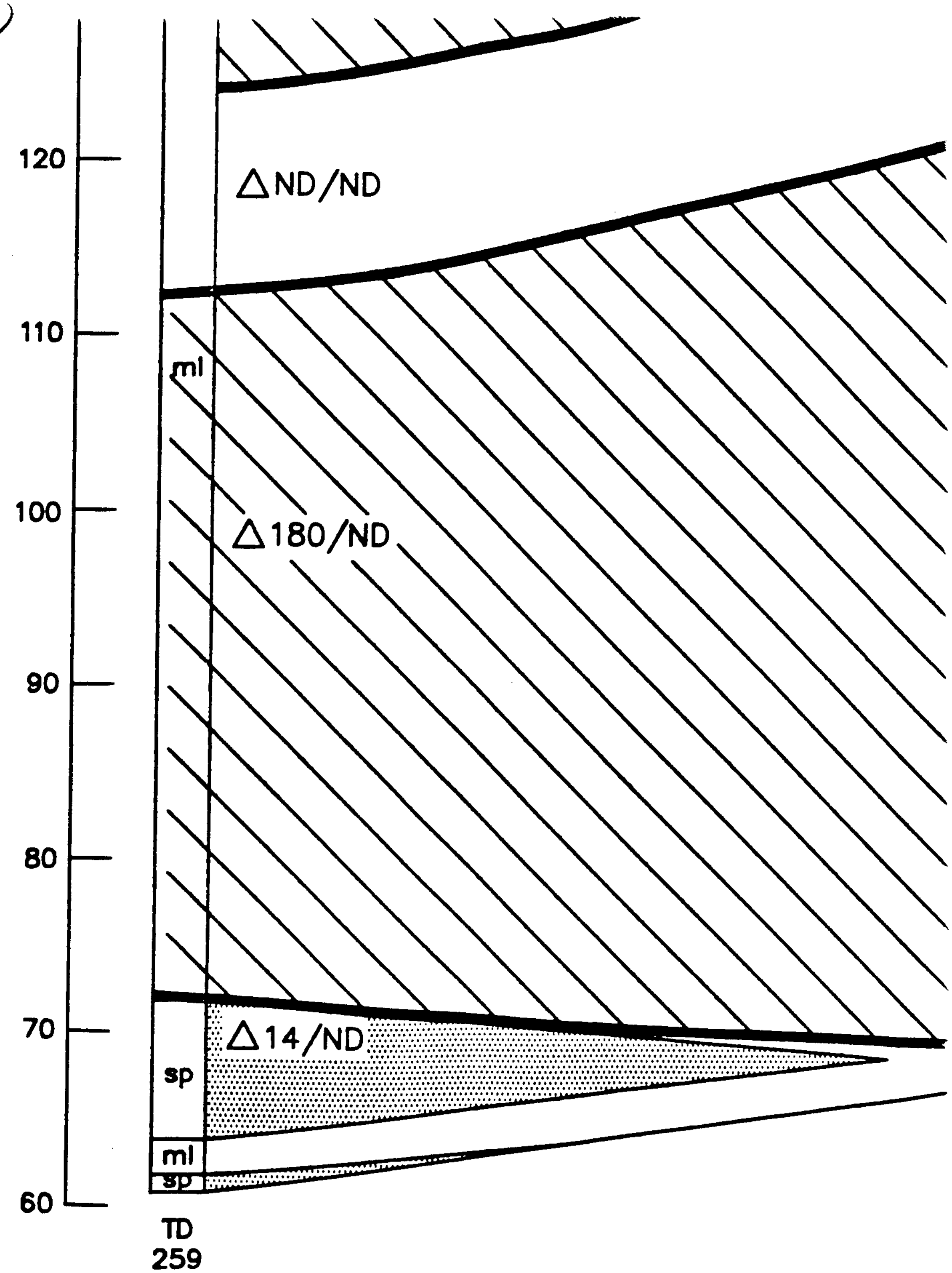
VERTICAL SCALE

STARTING DATE: 10/19/

DRAWN BY: SCHAEFFER

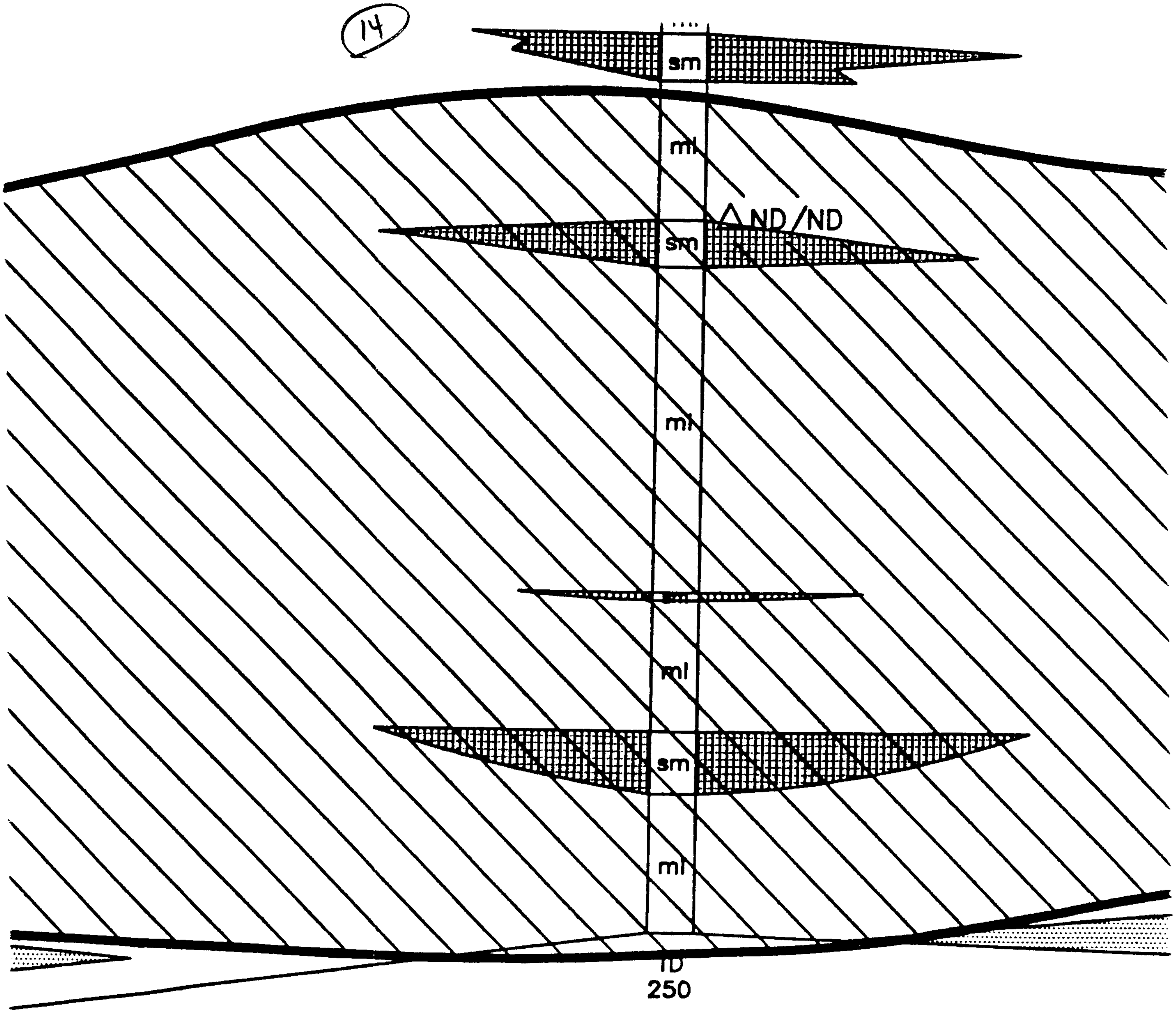
97240140 4/10/96 7:25Am DAA

13

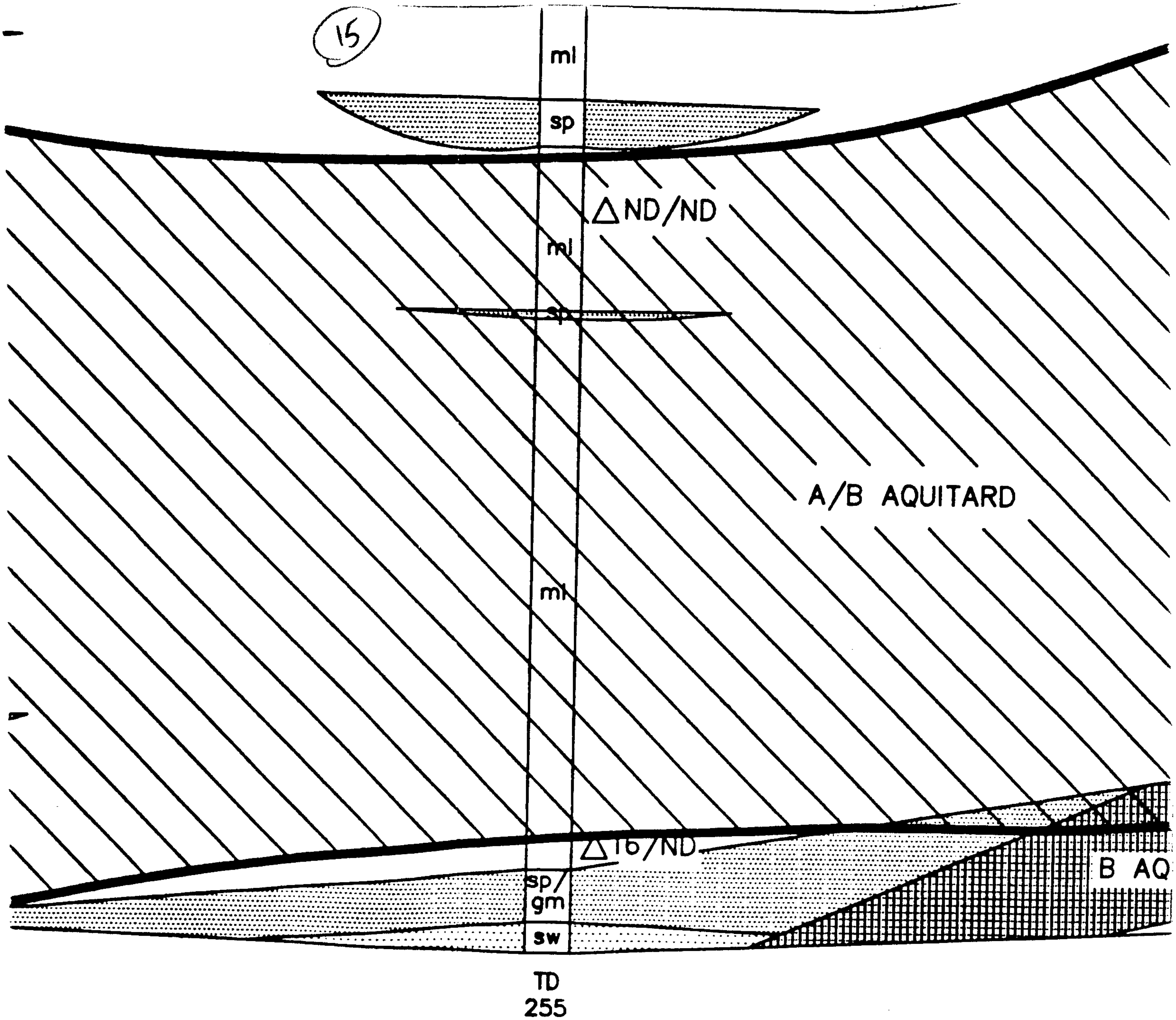


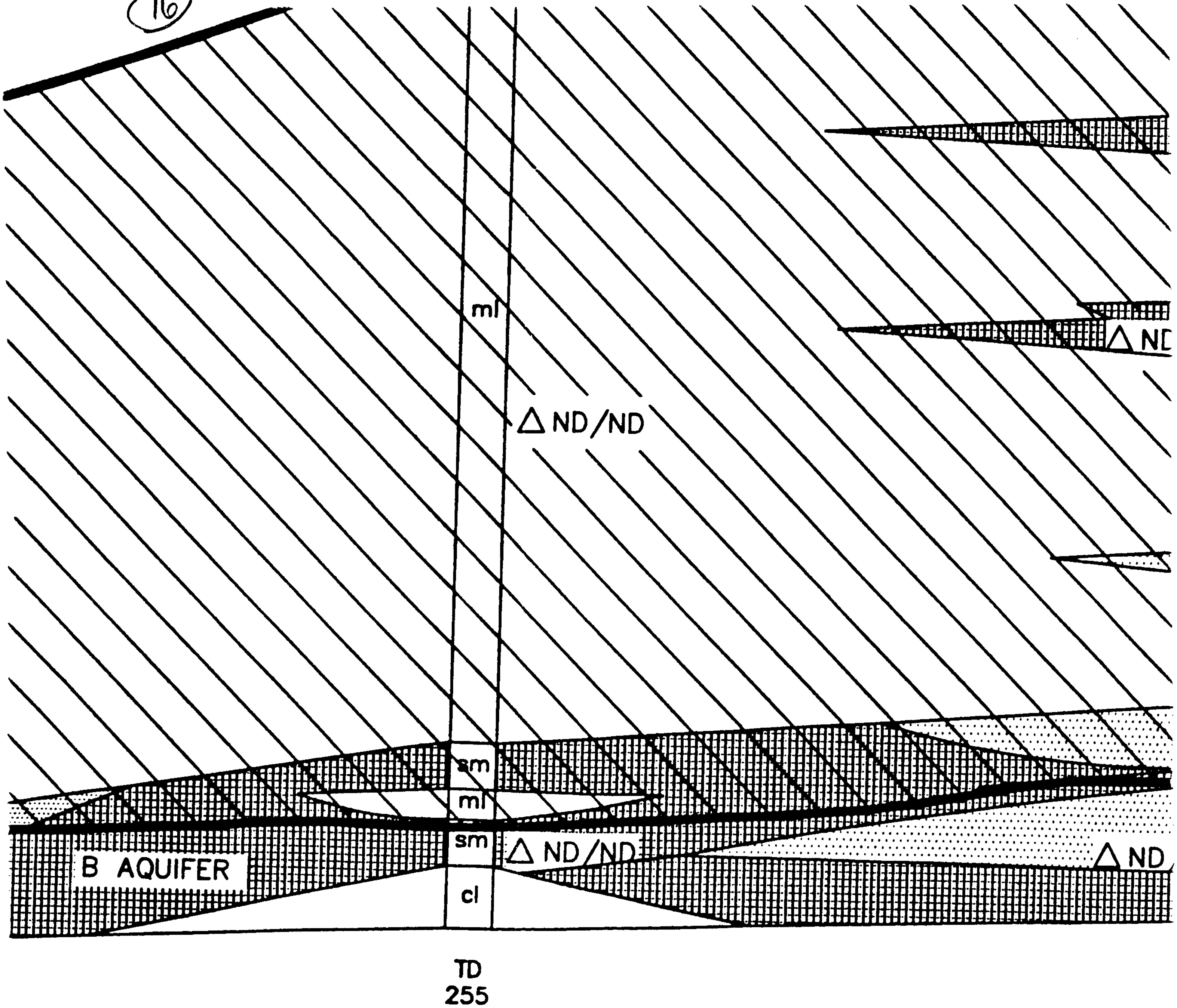
(FAN-XS4 409724-E3)

(14)



15




ml
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sm
ml
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B AQUIFER
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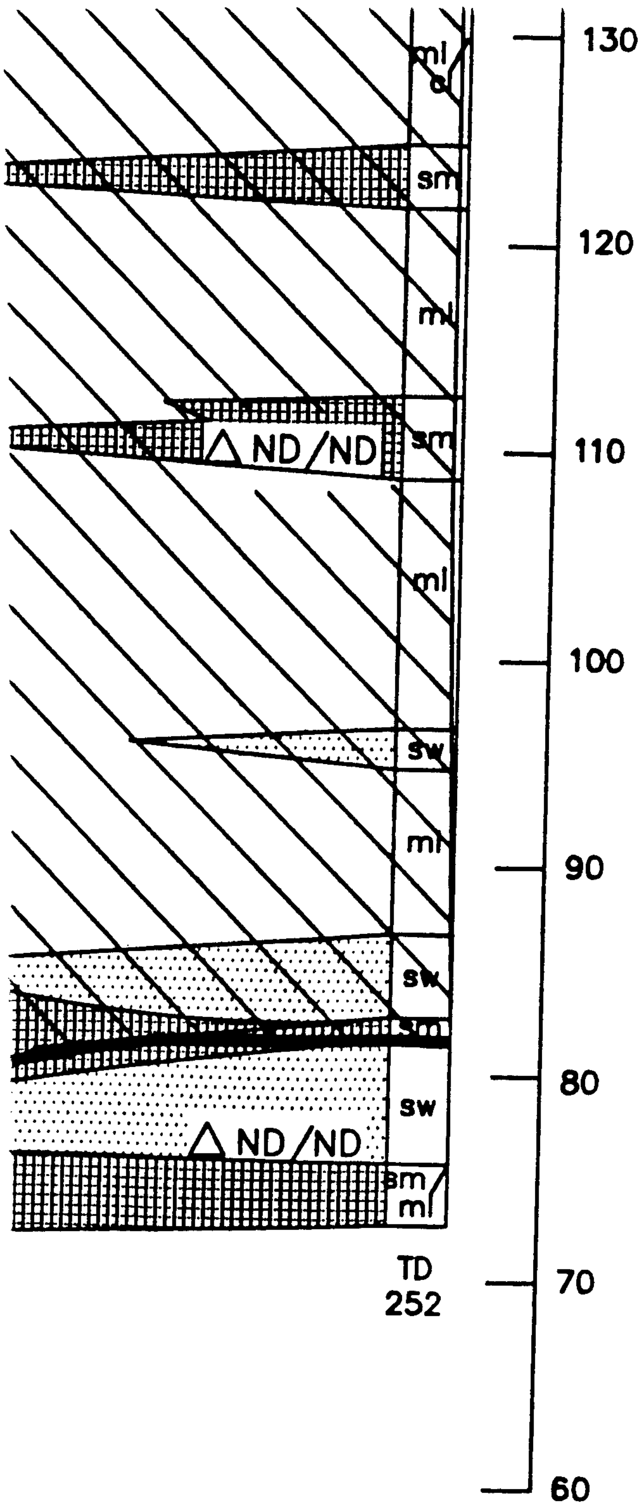
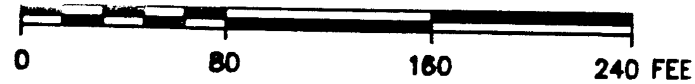
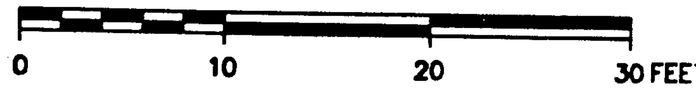
TD
255

17





VERTICAL SCALE



VERTICAL EXAGGERATION = 8X

FIGURE 5-3

DEEP AQUIFER H
CROSS SECTION
MONITORING WELL
CHEMICAL DATA

CALIFORNIA AIR NATIONAL
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

(18)

80 160 240 FEET

VERTICAL SCALE

10 20 30 FEET

VERTICAL EXAGGERATION = 8X

RE 5-3

) AQUIFER HYDROGEOLOGIC
SS SECTION WITH
TORING WELL AND
MICAL DATA

RNIA AIR NATIONAL GUARD
) AIR TERMINAL
), CALIFORNIA

TERNATIONAL
CHNOLOGY
RPORATION

5.3.2.1 Interpretation Overview

There are two main aquifers as interpreted from the available information, and they have been assigned a designation of "A" and "B" aquifers. In total, the A aquifer is 120 to 130 feet thick, extending from the water table, at 245 feet msl to an elevation of 115 feet msl. The A and B aquifers are separated by a thick aquitard, up to 65 feet thick, consisting of hard, compacted silt with little moisture.

The A aquifer, based on the presence of several discontinuous aquitards within it, is divided into three general subaquifers, which are designated, in order of depth, A1, A2, and A3 aquifers. The A1 aquifer is also generally referred to as the water table aquifer. None of the separating aquitards appear to be laterally continuous, indicating that some degree of hydraulic communication occurs among them. The A1 aquifer (which may also be referred to as a subaquifer) ranges from 40 to 55 feet in thickness, from an elevation of 245 feet msl to 190 feet msl. Where it is distinguishable, the A2 aquifer ranges in thickness from 20 to 45 feet, and the A3 aquifer ranges from 15 to 35 feet in thickness.

Aquitards are labeled based on the subaquifers they separate. For example, the A1/A2 aquitard separates the A1 from the A2 subaquifer. The A/B aquitard separates the A from the B aquifer, noting that the A aquifer encompasses the entire section of A1, A2, and A3 subaquifers.

These designations are not to be confused with monitoring well labels. Monitoring wells were named at the time they were installed, which was before any hydrogeologic interpretation. Monitoring well labels do not denote the aquifers into which they were installed; however, the well name does denote relative depths. For example, well MWBP-09 is shallow, MWBP-09B is installed deeper, and MWBP-09C is installed to the greatest depth of the three wells. But all of the wells are installed in the upper portion of the A aquifer, in what is interpreted to be the A1 and A2 aquifers.

5.3.2.2 A Aquifer Interpretation

The A aquifer is interpreted to extend from the water table, at approximately 250 feet msl (80 feet bgs) to its deepest at about 120 feet msl (Figure 5-3) and generally corresponds to the upper Geologic Unit Number 1 (Section 5.3.1). The bottom boundary of the A aquifer is a very hard, dry silt unit that ranges from 35 to 60 feet in thickness. Sufficient isolation appears to be present between the units to be able to divide the section into two distinct aquifers: the A (water table aquifer), and the underlying B aquifer below 85 feet msl (Figure

5-3). The upper A aquifer is further divided into subunits based on the presence of several discontinuous aquitards. Because none of the aquitards within the A aquifer appeared to be laterally continuous, the entire section down to the thick silt layer was interpreted to constitute the A aquifer.

This interpretation is supported by deep groundwater screening and monitoring well sample data. In the northeastern portion of the section (EXB-01), TCE is constrained to relatively shallow depths at low concentrations. This suggests that there is a retarding layer within the upper reaches of the saturated zone between the upgradient source area and the northernmost portions of the Base. TCE is present at somewhat greater depths further downgradient, indicating vertical migration. This shows that aquitards in the area are discontinuous and the groundwater flow zones are connected to a degree. The lack of detections below an elevation of 170 feet msl in EXB-04 suggests some barrier to flow in the more southern direction, or more likely a preferential flow pathway to the southwest.

Divisions within the A aquifer were based on lithology, groundwater elevation, and chemical data. The three subaquifers are believed to be in at least partial communication due to the discontinuity of the aquitards. Aquifers include sand, silty sand, and silt, with the finer-grained lithologies yielding water in greater quantities than would normally be expected. The aquifers exhibit an apparent dip to the southwest, corresponding to the dip of units discussed in Section 5.3.1. The A aquifer, therefore, extends from the water table to approximately 120 feet msl (200 feet bgs). A repetitive sequence of coarse- and fine-grained sediment approximately 100 feet thick forms an interconnected sequence of aquifer and aquitard material that is divided into the A1, A2, and A3 aquifers. Continuous sand layers are present, forming pathways for lateral groundwater flow and potential contaminant migration. Consolidated fine-grained aquitards within the larger silt units form potential barriers to vertical flow. In some cases, coarser-grained lithologies are included as aquitard material. Boring logs that document hardness and saturation data for the exploratory borings are contained in Appendix F.

The aquitard units within the A aquifer appear to be discontinuous. The A1 aquifer includes approximately the upper 60 feet of the saturated zone. The base of the A1 aquifer is defined by a hard silt/silt-sand layer (A1/A2 aquitard) that extends across much of the section at an elevation of 200 feet msl (Figure 5-3). The A1/A2 aquitard was interpreted to be thin, and is potentially not present, within EXB-01. Downward migration through this thin retarding layer

is quite possible and would explain the presence of TCE at greater depths in EXB-01 and further downgradient.

The lower boundary of the A2 aquifer is defined at approximately 170 feet msl (154 feet bgs) by the A2/A3 aquitard. The A2/A3 aquitard is discontinuous with multiple thin layers rather than a single thick unit forming a flow barrier. The A2/A3 aquitard is not found in EXB-04, thus forming an interconnection to the A3 aquifer. However, TCE data within this zone (between elevations of 120 and 135 feet msl in borings EXB-04 and EXB-05) indicate some separation in flow systems in that TCE was not detected. There could also be a much stronger horizontal than vertical hydraulic gradient in this region, thereby decreasing the amount of TCE that reaches these lower elevations. The A3 aquifer is in turn bounded at its base by the A/B aquitard.

The A/B aquitard is a thick layer, up to 65 feet thick, of hard silt with little moisture. This unit appeared to effectively isolate the A and B aquifers. However, at isolated places within this formation, sufficient moisture was present to allow for collecting a groundwater screening sample (Figure 5-3). Additionally, groundwater screening samples did detect some amount of TCE both within and below the A/B aquitard in borings EXB-03 and EXB-05. This information indicates that some groundwater flow and contaminant transport does indeed occur through this aquitard (i.e., it is a leaky aquitard). It is, therefore, better described as a unit in which a well would yield very low volumes of water, but that allows sufficient flow and connection to carry groundwater and its constituents to greater depths.

Given this data interpretation, it can now be determined what portions of which subaquifers are sampled in each monitoring well. Monitoring wells that are screened across the water table penetrate the first 10 to 15 feet of the A1 subaquifer. Monitoring wells assigned a "B" suffix have been installed near the bottom of the A1 subaquifer (Figure 5-3). Monitoring wells with a "C" suffix are installed into the A2 subaquifer. No monitoring wells have been installed into the A3 subaquifer or into the B aquifer as a part of investigation programs conducted at the Base.

5.3.2.3 B Aquifer Interpretation

The upper surface of the A/B aquitard in the vicinity of EXB-05 is uncertain. Geologic characteristics from this depth (112 feet msl) indicate moist to slightly moist conditions in the silt body, and may have a sand lens at an elevation of 102 feet msl. It is possible that the

A/B aquitard actually begins underneath the potential sand lens, in which case the upper surface of the A/B aquitard at EXB-05 would begin at an elevation of 100 feet msl.

The A/B aquitard, which corresponds to Geologic Unit No. 2, forms a concave surface between 150 and 120 feet msl. The lower surface of the unit expresses a concave cross section with an elevation ranging from 65 to approximately 80 feet msl. The coarse-grained unit below this aquitard is designated the B aquifer. The exploratory borings extended less than 15 feet into the B aquifer; therefore, the base of the unit is undefined. From the available data, B aquifer lithologies include materials similar to the A aquifer, with a large proportion of sands and silty sands. The upper portion of the B aquifer also appears to have a greater percentage of gravel than the A aquifer. Lithologic units also appear to have a southwest-trending dip.

5.3.3 Deep Groundwater Flow Patterns

Groundwater elevations have been measured among the well clusters over several time periods (Table 5-2). The latest measurement date is February, 1995. From the data in Table 5-2, it can be observed that groundwater elevations in the "A" and "B" wells (upper and lower portions of the A1 aquifer) are nearly identical (within instrument measurement error). This similarity between wells installed at average screen elevations 25 feet below the water table wells indicates an almost horizontal flow pattern across the section.

Groundwater elevations in deeper "C" wells (A2 aquifer) indicate a slight, but definite flow component between the upper and lower zones. At the upgradient well cluster (MWBP-09 series), there is a very slight upward gradient from the lower to the upper zone. This may be caused by a previously theorized discontinuous retarding layer at some intermediate depth upgradient of Base property. This upward hydraulic gradient may also explain why TCE is restricted to shallower groundwater depths at this location.

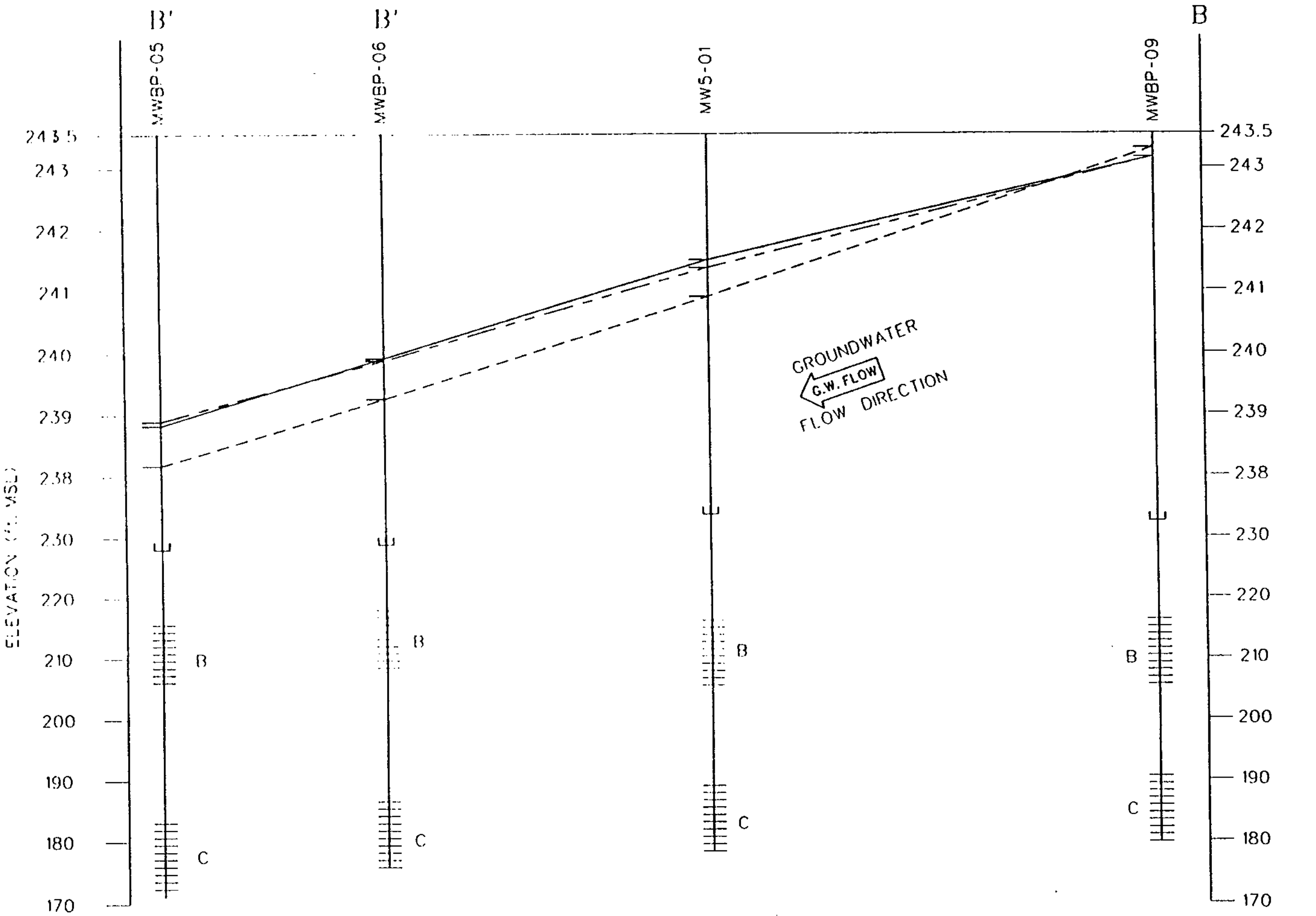
Further downgradient to the southwest, the vertical gradient changes to a definite downward direction. Vertical gradients are greatest at the MWBP-06 series wells, whereas the smallest vertical gradient is measured at the MW5-01 cluster. This observation shows that the potential for vertical migration of groundwater, and its constituents, increases as it moves away from Site 5-BCP. A hydraulic cross section of groundwater elevations among the well clusters is shown in Figure 5-4, which graphically exaggerates differences in groundwater elevations between upgradient and downgradient locations on Base. Plan-view depictions of

Table 5-2

Well Cluster Groundwater Elevation Measurements
California Air National Guard - Fresno, California

(All measurements in feet msl)

WELL ID	MEASUREMENT DATE:				
	12/06/93	01/05/94	03/11/94	12/06/94	02/15/95
MWBP-09	245.74	245.52	245.33	242.66	243.16
MWBP-09B	245.72	245.60	245.33	242.61	243.16
MWBP-09C	245.81	245.59	245.45	242.69	243.31
MW5-01	243.13	242.95	243.24	240.09	241.50
MW5-01B	243.05	242.91	243.17	240.02	241.37
MW5-01C	242.77	242.75	242.93	239.82	240.87
MWBP-05	240.14	240.13	240.76	237.59	238.82
MWBP-05B	240.30	240.26	240.88	237.69	238.89
MWBP-05C	239.70	239.72	240.26	237.07	238.17
MWBP-06A	242.00	241.57	241.78	238.75	239.92
MWBP-06B	242.00	241.56	241.74	238.78	239.88
MWBP-06C	240.88	240.76	240.72	238.21	239.25



LEGEND:

SCREEN INTERVAL FOR B/C WELLS

BOTTOM OF SCREEN FOR WATER TABLE WELL

WATER LEVEL IN WATER TABLE WELL

WATER LEVEL IN "B" WELL

WATER LEVEL IN "C" WELL

NOTE:

VERTICAL SCALE: AS NOTED

HORIZONTAL SCALE:

0 400 800 FEET

FIGURE 5-4

HYDRAULIC CROSS-SECTION B-B' FOR MEASUREMENTS IN FEBRUARY, 1995

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STARTING DATE 10/15/95 | DATE LAST REV | DRAFT CHCK BY D. PACHECO | INITIATOR S. LOGAN | CAD NO. 409724ES.020
DRAWN BY: D. BILLINGSLEY | DRAWN BY | ENGR CHCK BY S. LOGAN | PROJ. MGR D. BURTON | PROJ. NO. 409724.035.03.004

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groundwater flow directions in the "B"-well and "C"-well zones (lower A1 and A2 aquifers) are included in Appendix E.

5.3.4 Aquifer Testing Results

The previous discussions dealt with the saturated zone from the water table to depths 190 feet below the water table. Pump tests were performed in one well installed at the water table and in one well installed 20 feet beneath the water table. The following discussions, therefore, focus on the upper portions of the saturated zone. Additionally, the following discussions are a summary of pertinent information and conclusions from the pumping test activities discussed in detail in the groundwater sampling/pump test technical memorandum (IT, 1996b).

As outlined in Section 4.5.5, activities associated with the pump tests included piezometer installation, background water level monitoring, step-drawdown tests and long-term tests. Pump tests were conducted in wells MWBP-12 and MWBP-05B; step-drawdown tests were performed first, followed by longer-term, constant discharge rate tests. Reasons for selecting these two wells included their location within the contaminant plume, depth of installation, type of material screened, and well diameter.

5.3.4.1 Background Water Level Monitoring Results

Water level fluctuations were measured in two background wells that are screened in the same formation as the wells to be tested (MWBP-09 and MWBP-09B, Figure 4-6). Measurements were recorded every 20 minutes for the duration of the testing activities. Additionally, barometric pressure readings from the nearby National Weather Service station were obtained for the testing period. Barometric pressure and background water level fluctuations for the entire recording period are shown in Figure 5-5.

Until the present time, the first occurrence of water has been referred to as the water table, which assumes unconfined conditions. However, the marked correlation between atmospheric pressure changes and water level changes suggests a confined or semiconfined condition (Todd, 1980; Davis and DeWeist, 1966). Observations by several researchers (among others, Ferris et al., 1962; Turk, 1975) indicate that if a layer or bed of low permeability lies between the water table and ground surface, then air flow is restricted. This implies that atmospheric pressure changes could not be instantaneously absorbed into the groundwater surface and a resulting fluctuation in the water level due to barometric pressure loading would be observed. This is the case at the Base. Figures 5-1 and 5-2 show that fine-grained (silt) material is

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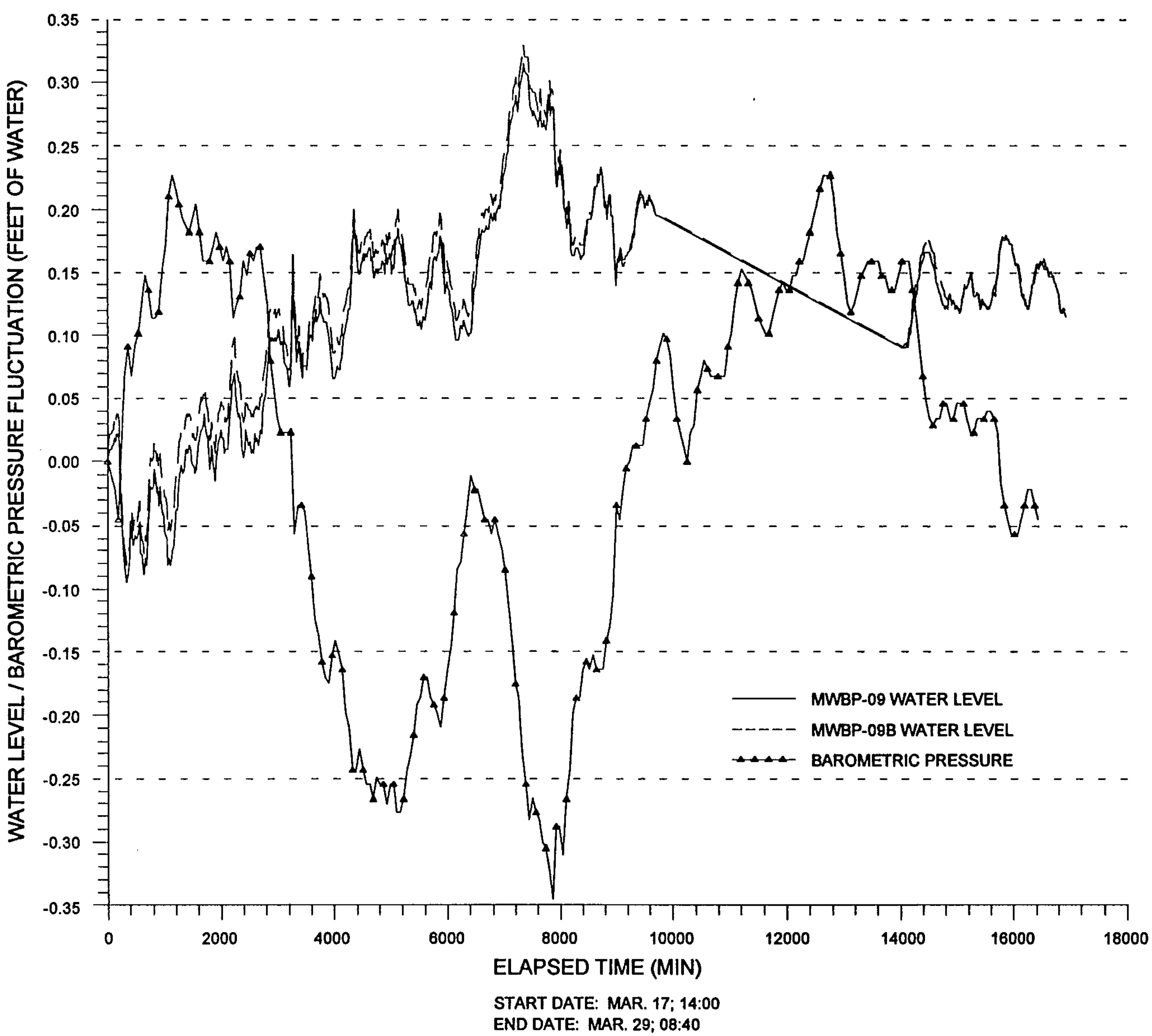

NOTES:

MWBP-09B SCREENED AT SAME DEPTH INTERVAL AS MWBP-05B

MWBP-09 SCREENED ACROSS THE WATER TABLE

BAROMETRIC PRESSURE READINGS PROVIDED BY THE NATIONAL WEATHER SERVICE, FRESNO AIR TERMINAL

FIGURE 5-5
BACKGROUND WATER LEVEL AND BAROMETRIC PRESSURE FLUCTUATIONS OVER TEST PERIOD

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present immediately above the groundwater surface. Yet, correlations of water level fluctuations to barometric pressure loading cannot, by themselves, determine whether the aquifer type penetrated by a well is unconfined or semiconfined (Rojstaczer and Riley, 1990). This determination can only be made by pumping tests and a thorough knowledge of the hydrogeologic setting.

5.3.4.2 Step-Drawdown Test Results

Step-drawdown tests were conducted in order to select the pumping rate to be used during longer-term, constant discharge rate tests. The wells in which these tests were conducted were 4- and 5-inch diameter monitoring wells with limited screen lengths. They are not considered production wells and were not designed as such; therefore, well efficiency and well loss characteristics were not evaluated. Step-drawdown tests allowed for an assessment of the practical yield capabilities of both MWBP-12 and MWBP-05B. Also, the test in MWBP-05B allowed for observations on the degree of interconnection within the A1 aquifer zones at that location.

The objective of determining the hydraulic communication within the A1 aquifer was met with the test in MWBP-05B. Figure 5-6 shows the graph of drawdown in the pumping well (MWBP-05B) during its step-drawdown test. The response of a nearby piezometer screened at the lower aquifer section that was pumped (P-3B) and the response of a nearby piezometer screened at the water table (P-4A) are shown in Figure 5-7. As shown in Figure 5-7, the piezometer screened at the water table responds almost instantaneously to pumping in the lower sediments. The hypothesis that the two depths of wells are installed in the same aquifer is correct at this particular location.

Recovery data were collected after the step-drawdown tests were finished. An analytical technique was used for evaluating aquifer properties based on recovery data after step-type pumping (Kawecki, 1993). This is integrated into the following section.

5.3.4.3 Constant Rate Test Results

Constant rate tests were conducted in MWBP-12 and MWBP-05B. The test in MWBP-12 was conducted for 20 hours at a pump rate of 7.5 gpm. Well MWBP-05B was tested for 36 hours at 16 gpm. Water levels were monitored in the pumping well and in several nearby observation points around each well. Recovery data were also recorded. Drawdown measurements were compared to background water level fluctuations that occurred during each test and the data were adjusted based on the background fluctuations.

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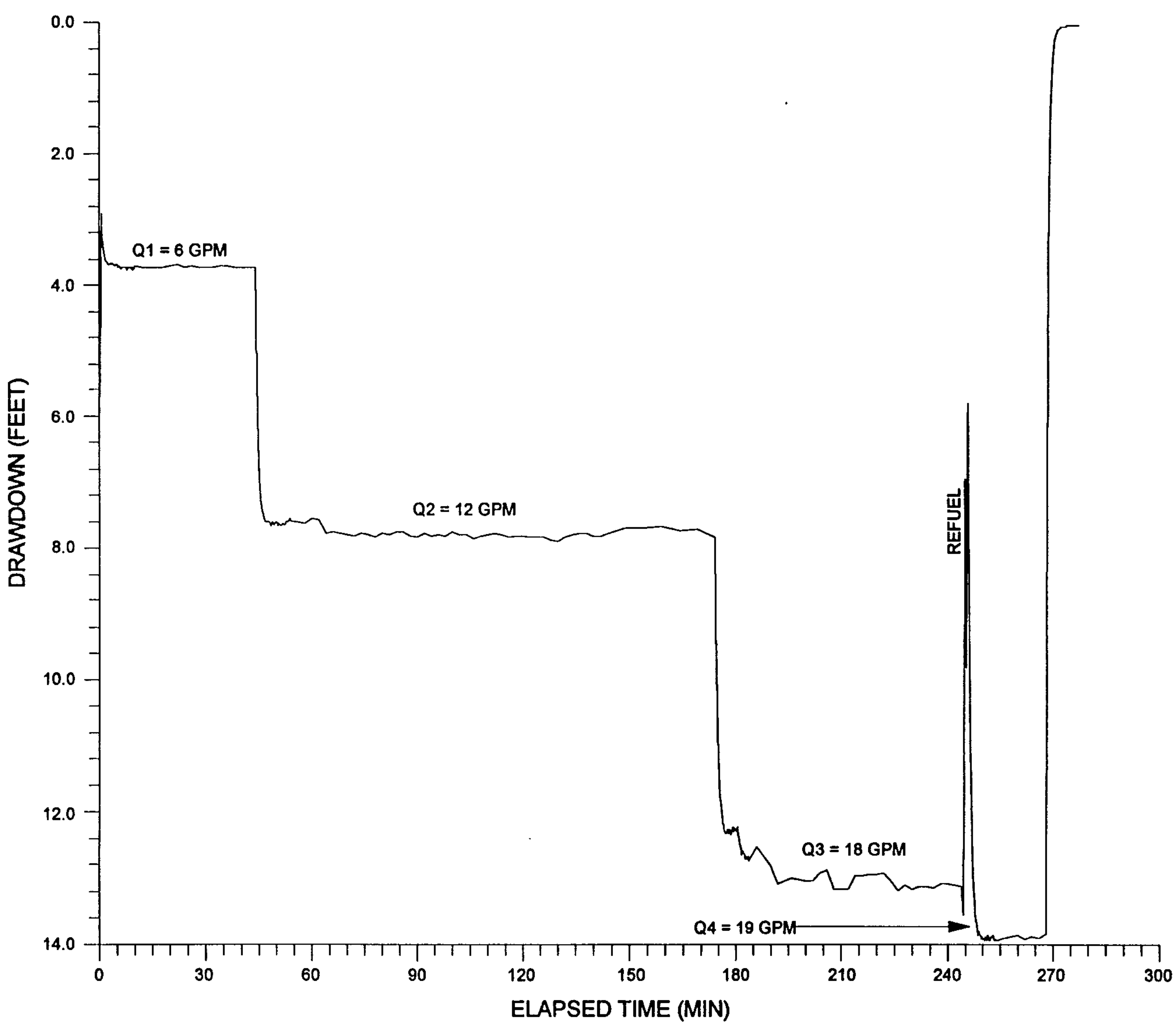

FIGURE 5-6
STEP-DRAWDOWN TEST RESULTS IN MWBP-05B

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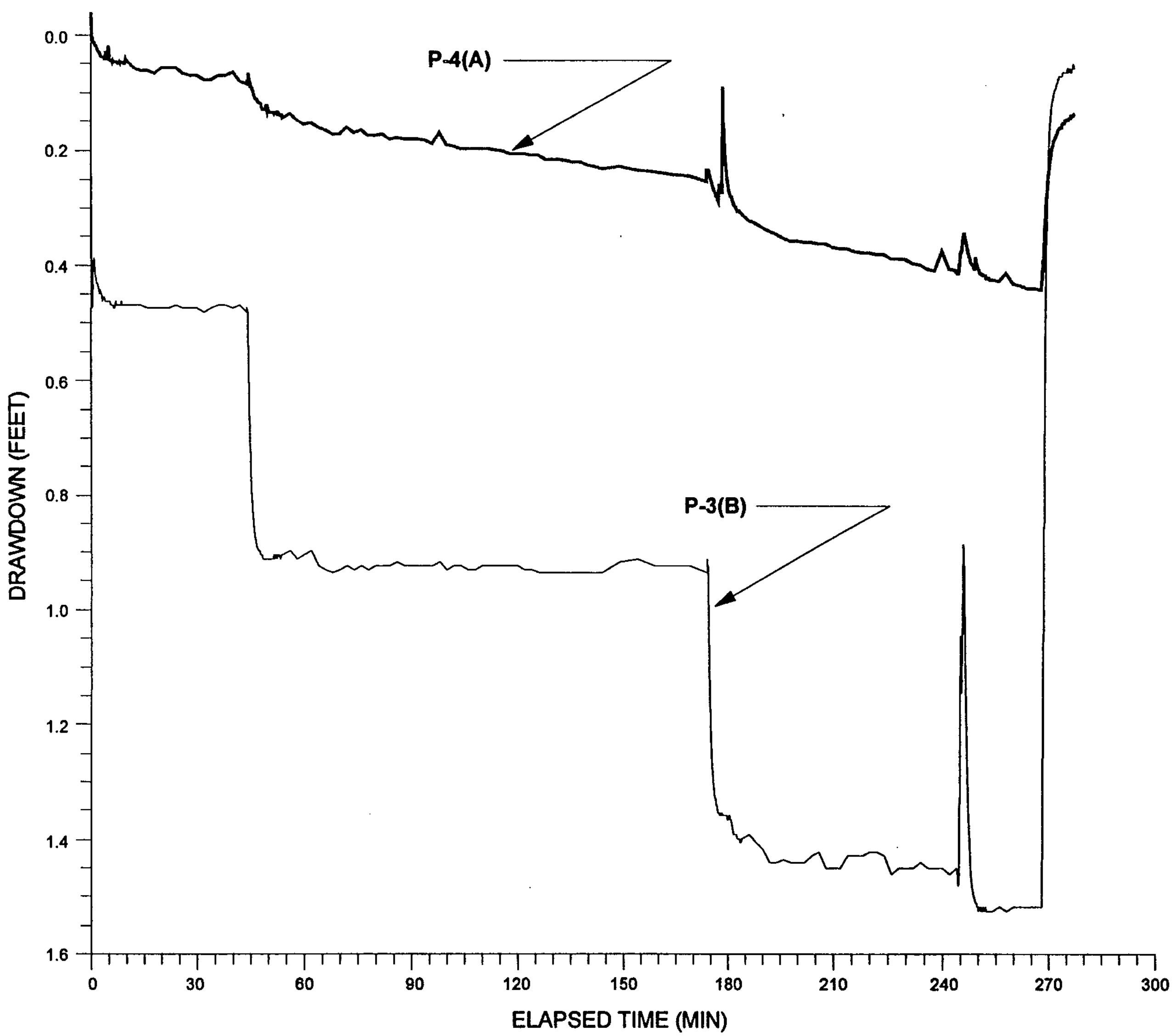

NOTES:

P-3(B) SCREENED AT SAME DEPTH INTERVAL AS MWBP-05B

P-4(A) SCREENED ACROSS THE WATER TABLE

FIGURE 5-7

DRAWDOWN MEASUREMENTS IN P-3(B) AND P-4(A) DURING STEP-DRAWDOWN TEST IN MWBP-05B

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A detailed discussion on justification and rationale for the methods used in analyzing each observation data set (both drawdown and recovery analyses) is included in the technical memorandum (IT, 1996b). Pumping test data are also presented in their entirety in IT (1996b). Analyses of various pumping test data sets are provided in Appendix H. Table 5-3 lists aquifer parameters calculated using several analytical methods for each observation data set. Average aquifer property values are derived from only parameter estimates obtained from the pumping phase of each test. Parameter estimates calculated from recovery data are not used for calculating average property values. Table 5-4 synthesizes the results from each set of results for each well/depth interval tested.

As presented in Table 5-4, a representative transmissivity (T) value for the shallow sediments at MWBP-12 is 460 square feet per day (ft^2/day); a representative storage coefficient (S) at this same location is 0.003. At MWBP-05B, analyses can be divided into shallow and deep sediment properties, which can also be combined. Shallow material at MWBP-05B have an average T of 2,070 ft^2/day with an S of 0.014. Based on the analyses of observation points screened in the deeper sediments, an average T for the deeper sediments is 825 ft^2/day with an S of 0.0002. Averaging the shallow and deep properties at the MWBP-05B location gives a T of 1,450 ft^2/day and an S of 0.007, which provides a reasonable estimate of aquifer properties through the entire thickness of the A1 aquifer at MWBP-05B.

The range of values calculated for both deep and shallow zones of the A1 aquifer shows the heterogeneity of the A1 aquifer, as is expected from the alluvial type aquifer composition. At MWBP-12, shallow sediments have an average T of 460 ft^2/day, whereas near MWBP-05B, shallow sediments have an average T of 2,070 ft^2/day, illustrating the anisotropic nature of the aquifer.

During the test in MWBP-05B, water levels were measured in nearby deep wells MWBP-05C (screened 20 to 30 feet below the bottom of the pumping well, in the A2 aquifer) and HFMW-05D (screened 220 feet below the bottom of the pumping well) (Figure 4-9). Figure 5-8 includes the water level fluctuations recorded in these two wells and in a background well (MWBP-09B) during the test in MWBP-05B. Figure 5-8 shows that no drawdown response was induced in either MWBP-05C or HFMW-05D when pumping MWBP-05B. This is more significant in MWBP-05C than in HFMW-05D. Two hypotheses are proposed for the lack of response in MWBP-09C, neither of which can be proved or disproved from the pump test: (1) the pumping rate of 16 gpm was insufficient to alter the deeper potentiometric lines, i.e., no significant upward flow was created to the pumping well; or (2) a barrier to flow exists

Table 5-3

Aquifer Test Analysis Summary
California Air National Guard - Fresno, California

Pumping Well ID	Observation Well ID	Analytical Model	Model Type	Data Set	Transmissivity, T (ft^2/day)	Storativity	Average T[a] (ft^2/d)
MWBP-12	MWBP-12	P-Cooper[b]	Confined, large diameter well	Drawdown	168		250
		Jacob straight line	Confined	Drawdown, late time data	328		
		Theis recovery	Confined	Recovery	60		
		Kawecki	Confined/unconfined	Step-drawdown recovery	89		
	P-1	Theis	Confined	Drawdown	703	.0033	700
		Theis recovery	Confined	Recovery	619		
	P-2	Theis	Confined	Drawdown	2206	.063	2200
		Theis recovery	Confined	Recovery	5818		
	P-1/P-2	Thiem-Dupuit	Confined/unconfined	Distance-drawdown	420		420
MWBP-05B	MWBP-05B	P-Cooper	Confined, large diameter well	Drawdown	359		1085
		Jacob straight line	Confined	Drawdown, late time data	1811		
		Theis recovery	Confined	Recovery	68		
		Kawecki	Confined/unconfined	Step-drawdown recovery	62		
	P-3B	Hantush-Jacob	Leaky confined	Drawdown	846	.0002	740
		Walton	Leaky confined	Drawdown	931	.0002	
		Hantush modification	Confined, partial penetration	Drawdown	441		
		Theis recovery	Confined	Recovery	533		
	P-5B	Jacob straight line	Confined	Drawdown, late time data	5653	.0002	5415
		Theis	Confined	Drawdown	5176	.0002	
		Theis recovery	Confined	Recovery	9893		
	P-3B/P-5B	Theim-Dupuit	Confined	Distance-drawdown	650		650
	P-4A	Theis	Confined	Drawdown	2414	.004	2410
		Theis recovery	Confined	Recovery	4147		
	MWBP-05	Theis	Confined	Drawdown	2414	.024	2410
		Theis recovery	Confined	Recovery	6896		
	P-4A/MWBP-05	Thiem-Dupuit	Confined	Distance-drawdown	1410		1400

[a]T values calculated from recovery data are not used to calculate an average T.
[b]Papadopulos-Cooper.

Table 5-4

Calculated Average Properties
California Air National Guard - Fresno, California

Location/Zone	Test Wells	T (ft^2/day)	S	
MWBP-12/Shallow Sediments, A1 Aquifer	MWBP-12	250		
	P-1	700	0.003	b[b] = 45 ft
	P-2[a]	Not used		K[b] = T/b = 10.2 ft/day
	Thiem-Dupuit	420		
	Average T, S	460	0.003	
MWBP-05B/Deeper Sediments, A1 Aquifer	MWBP-05B	1085		
	P-38	740	0.0002	Average of entire section of the A1 aquifer:
	P-5B[c]	Not used		T = 1450 ft^2/day S = 0.007
	Thiem-Dupuit	650		
	Average T, S	825	0.0002	
				b = 45 ft K = T/b = 32 ft/day
MWBP-05B/Shallow Sediments, A1 Aquifer	P-4A	2410	0.004	
	MWBP-05	2410	0.024	
	Thiem-Dupuit	1400		
	Average T, S	2070	0.014	

[a]P-2 not used due to very small drawdown and unreasonably high T values.
[b]b = aquifer thickness.
K = hydraulic conductivity.
[c]P-5B not used due to erratic data pattern and unreasonably high T values.

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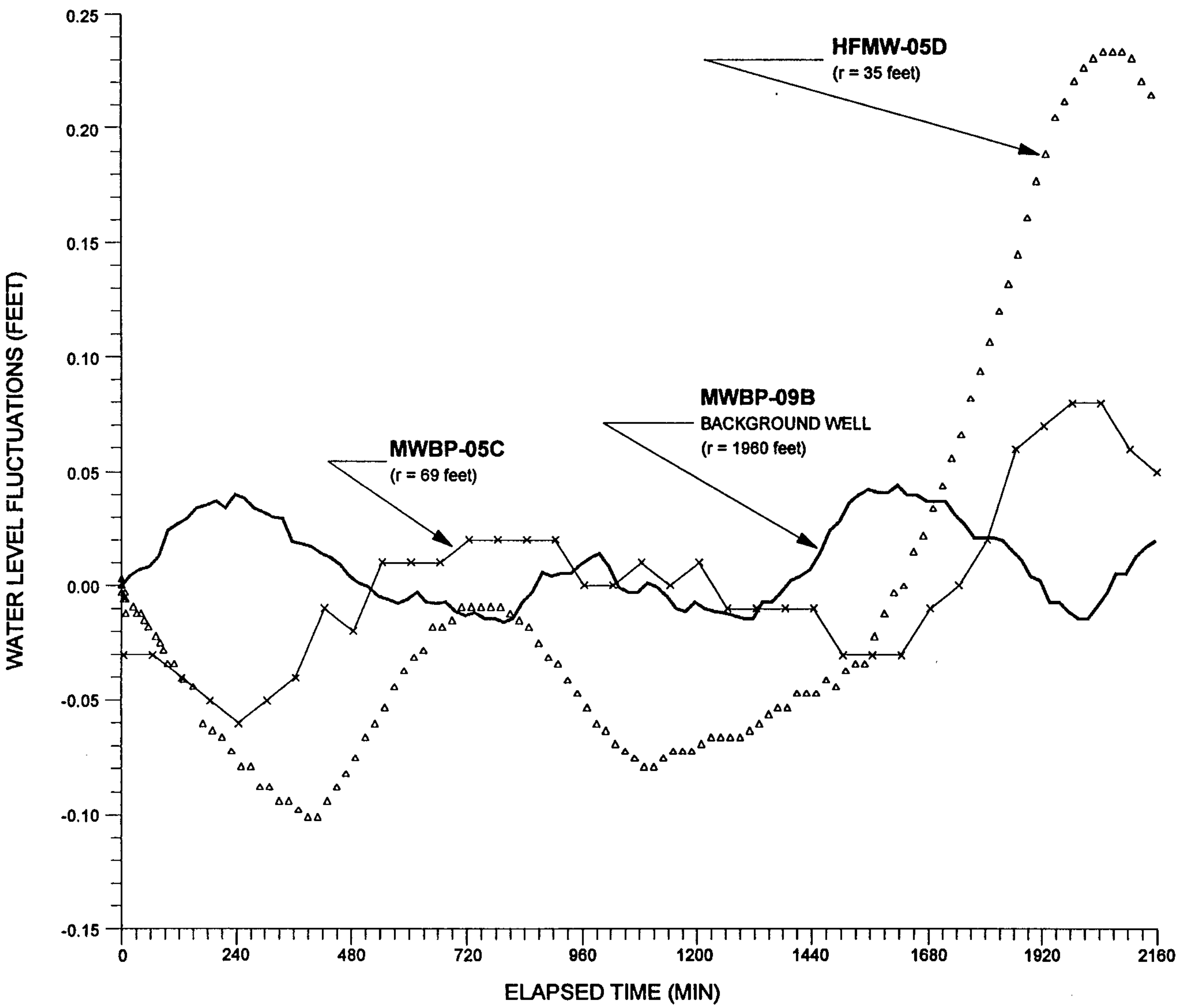

NOTES:

MWBP-09B SCREENED AT SAME DEPTH INTERVAL AS MWBP-05B

MWBP-05C SCREENED 20 FEET BELOW THE BOTTOM OF MWBP-05B

HFMW-05D SCREENED 220 FEET BELOW THE BOTTOM OF MWBP-05B

PUMPING RATE IN MWBP-05B IS 16 GPM

FIGURE 5-8
WATER LEVEL FLUCTUATIONS IN MWBP-05C AND HFMW-05D DURING CONSTANT RATE TEST IN MWBP-05B

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between MWBP-05B and MWBP-05C, i.e., an aquitard separates the two flow systems. Deep monitoring well chemical sampling data (Section 6.4.2) tends to support the second hypothesis because PCE was detected in the pumping well but not in the deeper well (MWBP-05C).

If a barrier to flow does exist between the lower A1 and A2 aquifer, it is likely a fine-grained silt layer above well MWBP-05C, that is shown in Figure 5-3. Figure 5-3 displays an aquitard unit that is present between wells MWBP-06B and MWBP-06C, and between MW5-01B and MW5-01C. This aquitard unit may very well extend beneath MWBP-05B as suggested from the response in the deeper well from pumping in MWBP-05B. The top elevation of this layer is approximately 194 feet and groundwater is measured at 239 feet. Therefore, the aquifer thickness (b) is 45 feet. Since hydraulic conductivity (K) is equal to T/b, a K value at MWBP-12 is 10.2 ft/day and is 32 ft/day near MWBP-05B (Table 5-4).

When compared to K values derived from slug tests conducted during the RI (Table 5-1), K values from the pump tests appear reasonable. Slug tests were analyzed with the assumption that the aquifer was approximately 15 feet thick; however, this has only a minor bearing on the final K value. Based upon further examination of aquifer recovery during slug testing too detailed to present here, it appears that the K values calculated from slug tests are overestimates of actual values by a factor of 2 to 4.

6.0 Investigation Findings

As established in Chapter 4.0, four general field events comprise the RI activities at the Base: Site 5-BCP investigation, quarterly groundwater sampling of water table monitoring wells, the initial deep aquifer investigation, and aquifer/pumping tests. Results of the pumping tests are included in Section 5.3.4. Findings from the other three general activities are included in this section. Also included is a discussion of background sampling and results.

6.1 Background Sampling Results

Analytical Data Discussion of Blank Correction and Data Validation. Data collected during the various field efforts were entered into a project-specific database. Field sample results within the database are linked to results from field and laboratory QC samples. These sample links allow for the data to be corrected for analytes that were also found in the QC samples. QC samples include field equipment rinsates, trip blanks, field blanks, and laboratory method blanks. When a QC sample contains a certain chemical and an associated field sample contains the same chemical at a similar or lower concentration, then that chemical is considered to be attributed to the sampling and analysis procedure and equipment, and not to the sampled matrix.

The database performs the comparison between field sample data and its associated QC samples. Through the comparison, the database conducts a "blank correction" on the field data and when a chemical is found in both the original and any of its associated QC samples, the field sample result is marked with a "B*" qualifier. This B* data is then removed from consideration in the final data interpretation because it does not represent site-specific conditions.

An organic chemical was removed from further consideration (was considered a nondetect value, or B*) if it was a common laboratory contaminant and the reported sample concentration was less than ten times the concentration in an associated QC sample (i.e., trip blank, field blank, equipment rinsate, or laboratory blank). Common laboratory contaminants include acetone, 2-butanone, methylene chloride, toluene, or phthalate esters. Other organic chemicals were considered to be not detected if results were less than five times the highest concentration detected in an associated QC sample.

Blank-corrected data have not been reported in any documents published to date. As a result, data summaries listed within this report may not contain the exact data as is listed in previous interim reports (such as IT, 1993b and 1993c) or technical memoranda (such as IT, 1994). A summary of the positive detections for all groundwater sample data collected over the project history and all of the fixed-base laboratory soil sample data collected during the RI at Site 5-BCP are listed in Appendix I. Sample results removed from this summary as a result of the blank correction process are included in Appendix I.

In addition to the blank correction, analytical data have been validated based on guidelines established in EPA (1988a; 1994a). Validation includes adding data qualifiers to inform data users of conditions in the laboratory setting that may have affected sample data. This might include conditions such as instrument calibration inconsistencies or holding times being exceeded. As a result of the validation process, users are assured that the data are valid and accurate to a high degree as indicated by the unique qualifiers. Data qualifiers used in the validation process and applied to the Fresno ANG data are explained in the following paragraph.

Chemical analytical data for Fresno ANG have been summarized in tables throughout the text. These summary tables only contain those target compounds that were detected at any level. They do not include samples with a "B*" qualifier, or any tentatively identified compounds. Summary tables also do not contain results that have a "U" qualifier of any kind, i.e., not detected at the indicated concentrations ("U" or "UJ"). A listing of the parameters tested for each analytical method used during the RI and groundwater sampling events is available in Appendix I.

6.1.1 Background Soil Results

The only soil samples collected for chemical analysis during the RI were at Site 5-BCP. Two soil borings were located hydrogeologically upgradient of the site (SB5-01 and SB5-10) and can be considered as background to Site 5-BCP. Background analytical ranges are more typically compiled for inorganics such as metals, which are naturally occurring. COC at Site 5-BCP are organic compounds not commonly found in soil. Therefore, the appropriate background values are considered to be not detected, i.e., the detection limit. Background soil sample results specific to Site 5-BCP are listed in Appendix I (Table I-2).

No inorganic data was collected from the RI and no background range compilation is necessary.

6.1.2 Background Groundwater Results

When evaluating groundwater conditions associated with quarterly groundwater sampling and the deep aquifer investigation, an area-specific range must be determined in order to evaluate the type and amount of contamination associated with the Base. Groundwater flows from the northeast towards the southwest. Groundwater along the northern Base boundary contains some amount of chlorinated organics and an area-specific background range can be calculated to determine the nature of the impact to groundwater attributable to the Base. Specifically, Sites 2 and 5 are directly downgradient of the northern Base boundary. This holds true whether the zone of concern is at the water table or is in a deeper zone.

Background wells located along the northern Base boundary are MWBP-01, MWBP-02, MWBP-03, MWBP-04, MWBP-09, MWBP-09B, MWBP-09C, and MWBP-10 (Figure 4-6). Each well except for MWBP-09B and MWBP-09C are water table monitoring wells. SVOCs, pesticides, and PCBs have been analyzed but never consistently detected in groundwater in the western portion of the Base. Therefore, background ranges in groundwater will consider only VOCs. Field duplicate sample results were not considered when calculating the concentration ranges. To better represent the entire data set, two sampling rounds from the SI were also used so that analytical data from a total of six sampling events were available.

Samples from the background water table wells detected three VOCs: TCE, 1,2-dichloropropane (DCP), and carbon tetrachloride. PCE has not been detected in any of the samples collected from these background wells. As indicated in Table 4-4, a total of 30 original VOC samples were collected from the background Base perimeter wells. TCE was detected in all 30 samples, 1,2-DCP in 21 samples, and carbon tetrachloride in 2 samples. Ranges of detected concentrations for VOCs along the Base Perimeter are summarized in Table 6-1. The following VOCs, therefore, are present in upgradient Base perimeter groundwater and are not considered to be related to past ANG activities at Sites 2 or 5:

- TCE
- 1,2-DCP
- Carbon tetrachloride.

6.2 Site 5-BCP Investigation Results

Results for the RI at Site 5-BCP are divided into screening and confirmation activity results (Sections 6.2.1 and 6.2.2, respectively). Section 6.2.3 is a discussion and comparison between the screening and confirmation sampling results for the soil sampling program.

Table 6-1

Summary of Detections, Upgradient Base Perimeter Monitoring Wells California Air National Guard - Fresno, California

Upgradient Well ID	Frequency of Detection	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)
TCE			
MWBP-01	6/6	7.7	11
MWBP-02	6/6	28	49
MWBP-03	6/6	130	210
MWBP-04	4/6	2	3.7
MWBP-09	3/3	450	520
MWBP-10	3/3	29	36
Sum	28/30		520
1,2-DCP			
MWBP-01	5/6	2.5	4.6
MWBP-02	6/6	2.6	5.2
MWBP-03	6/6	4.8	13
MWBP-04	1/6	1.1	1.1
MWBP-09	0/3	--	--
MWBP-10	3/3	2.4	2.9
Sum	21/30		5.2
Carbon Tetrachloride			
MWBP-01	0/6	--	--
MWBP-02	1/6	0.6	0.6
MWBP-03	1/6	0.8	0.8
MWBP-04	0/6	--	--
MWBP-09	0/3	--	--
MWBP-10	0/3	--	--
Sum	2/30		0.8

6.2.1 Screening Activity Results

6.2.1.1 Soil Organic Vapor Survey Results

No positive detections were reported for any shallow or deep SOV samples collected across the western portion of the Base. As such, results provided no guidance with which to focus the location of soil borings during the confirmation activities at Site 5-BCP. Documentation of SOV sample results is included in the interim report of findings focused RI (IT, 1993b).

6.2.1.2 Borehole Water Grab Sample Results

A total of seven groundwater grab samples were collected in October 1992 from open boreholes with standing groundwater for VOC analysis only. Samples were collected from the following boreholes: SB5-01, SB5-02, SB5-08, SB5-09, SB5-10, SB5-11, and SB5-12. Two of these boreholes (SB5-01 and SB5-02) were subsequently converted into monitoring wells (MW5-01 and MW5-02, respectively) and were later sampled in a more conventional and reproducible manner. A summary of the analytical results for these grab samples (also referred to as screening samples) is presented in Table 6-2.

TCE was detected in five of the seven screening samples at concentrations ranging from 3.8 micrograms per liter µg/L in SB5-09 to 190 µg/L in SB5-10, the furthest upgradient sample from Site 5-BCP. TCE was not detected in two samples (SB5-02 and SB5-08) collected immediately downgradient from Site 5-BCP (see Figure 4-3).

PCE was reported in six of the seven grab samples; PCE was not detected in one of the upgradient borings, SB5-10. This compound was reported at concentrations ranging from 3.9 µg/L in SB5-08 to 28 µg/L in SB5-09. The upgradient sample collected from SB5-01 detected PCE at a concentration of 21 µg/L, which is similar to the concentration detected in downgradient screening samples SB5-09 and SB5-12.

A natural breakdown product of TCE, cis-1,2-DCE, was detected in three of the screening samples: one directly east of Site 5-BCP (SB5-11 at 0.8 µg/L) and two downgradient from Site 5-BCP (SB5-09 at 1.3 µg/L and SB5-12 at 2.1 µg/L).

Results from these water screening samples are also discussed in conjunction with groundwater samples from monitoring wells during the RI (Section 6.2.2.2).

Table 6-2

Summary of Positive Detections in Site 5-BCP Borehole Water Screening (Grab) Samples California Air National Guard - Fresno, California

Sample ID: Date: Units:	SB5-01-GW 10/06/92 µg/L	SB5-02-GW 10/07/92 µg/L	SB5-08-GW 10/06/92 µg/L	SB5-09-GW 10/07/92 µg/L	SB5-10-GW 10/12/92 µg/L	SB5-11-GW 10/13/92 µg/L	SB5-12-GW 10/15/92 µg/L
VOC Parameter							
1,2-DCP[a]							2.4
Chloroform		0.9					
cis-1,2-DCE				1.3		0.8	2.1
PCE	21	4.2	3.9	28		24	15
TCE[a]	8.2			3.8	190	10	100

[a] Not a site-related chemical.

6.2.1.3 Site 5-BCP Soil Screening Sample Results

Screening samples were analyzed for VOCs. Screening results were used to select those soil samples that would be submitted to a fixed-base laboratory for analysis for VOCs, SVOCs, and TPH-d. Screening results were also used to determine the method for soil disposal (Section 4.7).

Site 5-BCP soil screening sample results are divided between borings located within the BCP and those on the perimeter or away from Site 5-BCP. Five borings were drilled around the top of Site 5-BCP (SB5-01, SB5-02, SB5-08, SB5-09, and SB5-11). One boring was located further upgradient (SB5-10) and one further downgradient (SB5-12); both were drilled primarily to collect groundwater screening grab samples from their open boreholes. Figure 4-3 shows the locations of the soil borings. A total of 103 soil screening samples were collected from the seven borings placed outside the extent of Site 5-BCP. None of the screening samples showed any detections of VOCs.

A total of 64 soil screening samples were collected from five borings located at the bottom of Site 5-BCP (SB5-03 through SB5-07). Of the VOCs analyzed, PCE was detected in 18 of 64 samples, TCE was detected in 12 of 64, and cis- or trans-1,2-DCE was detected in 2 of 64 samples. Table 6-3 lists the screening sample concentrations and the depths at which they were detected. lists the screening sample concentrations and the depths at which they were detected. lists the screening sample concentrations and the depths at which they were detected. lists the screening sample concentrations and the depths at which they were detected.

TCE was detected at concentrations ranging from 51 to 410 micrograms per kilogram (μg/kg), with an average detection of approximately 170 μg/kg. PCE was detected at concentrations ranging from 51 to 640 μg/kg, with an average detection of approximately 190 μg/kg. Detection limits for the screening samples were generally 50 μg/kg. Detections of TCE and PCE were sporadically distributed throughout the soil. They were not detected in any one boring from the top of the boring to the bottom (just above the water table); they were not consistently detected at any one particular depth interval.

The sporadic nature of the screening results indicates that the low level of contaminants detected are residual in nature. It can be seen from Table 6-3 that TCE was only detected in soil when PCE was detected. Due to this observation and the residual nature of the detec-

Table 6-3

Site 5-BCP Remedial Investigation - Soil Field Screening Laboratory Results California Air National Guard - Fresno, California

Sample Number	Date of Analysis	Results (μg/kg)[a]						
		1,1-DCE	trans 1,2-DCE	1,1-DCA	cis 1,2-DCE	1,2-DCA	TCE	PCE
SB5-01								
No detections in 15 samples								
SB5-02								
No detections in 15 samples								
SB5-03								
SB5-03-5.0'	09-29-92	<98[b]	<50	<50	<50	<50	<50	<50
SB5-03-10.0'	09-29-92	<95	<50	<50	<50	<50	254	329
SB5-03-15.0'	09-29-92	<107	<50	<50	<50	<50	<50	<50
SB5-03-20.0'	09-29-92	<98	<50	<50	<50	<50	56	115
SB5-03-25.0'	09-29-92	<96	<50	<50	<50	<50	<50	<50
SB5-03-30.0'	09-29-92	<101	<50	<50	<50	<50	<50	<50
SB5-03-35.0'	09-29-92	<70	<50	<50	66	<50	410	640
SB5-03-40.0'	09-29-92	<103	<50	<50	<50	<50	<50	<50
SB5-03-45.0'	09-29-92	<103	<50	<50	<50	<50	<50	<50
SB5-03-50.0'	09-29-92	<98	<50	<50	<50	<50	94	167
SB5-03-55.0'	09-29-92	<98	<50	<50	<50	<50	<50	85
SB5-03-60.0'	09-29-92	<136	<50	<50	<50	<50	<50	73
SB5-03-65.0'	09-29-92	<112	111	<50	<50	<50	285	270
SB5-04								
SB5-04-5.0'	10-01-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-10.0'	10-01-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-15.0'	10-02-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-20.0'	10-02-92	<50	<50	<50	<50	<50	<50	51
SB5-04-25.0'	10-02-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-29.5'	10-02-92	<50	<50	<50	<50	<50	61	63

Table 6-3

Site 5-BCP Remedial Investigation - Soil Field Screening Laboratory Results
California Air National Guard - Fresno, California

(Page 2 of 4)

Sample Number	Date of Analysis	Results (μg/kg)[a]						
		1,1-DCE	trans 1,2-DCE	1,1-DCA	cis 1,2-DCE	1,2-DCA	TCE	PCE
SB5-04 (continued)								
SB5-04-35.0'	10-02-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-40.0'	10-02-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-45.0	10-02-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-50.0'	10-02-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-55.0'	10-02-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-60.0'	10-02-92	<50	<50	<50	<50	<50	114	100
SB5-04-65.0'	10-02-92	<50	<50	<50	<50	<50	<50	<50
SB5-05								
SB5-05-4.5/5.0'	09-25-92	<80	<50	<68	<50	<50	<50	<50
SB5-05-9.5/10.0'	09-25-92	<77	<50	<58	<50	<50	<50	<50
SB5-05-14.5/15.0'	09-25-92	<71	<50	<54	<50	<50	<50	<50
SB5-05-19.0/19.5'	09-25-92	<68	<50	<52	<50	<50	<50	<50
SB5-05-24.5/25.0'	09-25-92	<78	<50	<53	<50	<50	<50	<50
SB5-05-29.5/30.0'	09-25-92	<69	<50	<51	<50	<50	51	138
SB5-05-34.5/35.0'	09-25-92	<77	<53	<50	<50	<50	<50	<50
SB5-05-39.5/40.0'	09-28-92	<77	<50	<50	<50	<50	122	219
SB5-05-44.5/45.0'	09-28-92	<77	<50	<50	<50	<50	<50	<50
SB5-05-49.5/50.0'	09-28-92	<66	<50	<50	<50	<50	<50	<50
SB5-05-54.5/55.0'	09-28-92	<73	<50	<50	<50	<50	<50	<50
SB5-05-59.5/60.0'	09-28-92	<68	<50	<50	<50	<50	<50	<50
SB5-05-64.5/65.0'	09-28-92	<72	<50	<50	<50	<50	<50	<50

Table 6-3

Site 5-BCP Remedial Investigation - Soil Field Screening Laboratory Results California Air National Guard - Fresno, California

(Page 3 of 4)

Sample Number	Date of Analysis	Results (μg/kg)[a]						
		1,1-DCE	trans 1,2-DCE	1,1-DCA	cis 1,2-DCE	1,2-DCA	TCE	PCE
SB5-06								
SB5-06-5.0'	09-28-92	<81	<50	<50	<50	<50	<50	<50
SB5-06-10.0	09-28-92	<90	<50	<50	<50	<50	<50	<50
SB5-06-15.0'	09-28-92	<73	<50	<50	<50	<50	<50	<50
SB5-06-20.0'	09-28-92	<71	<50	<50	<50	<50	<50	<50
SB5-06-25.0'	09-28-92	<67	<50	<50	<50	<50	216	357
SB5-06-30.0'	09-28-92	<63	<50	<50	<50	<50	156	297
SB5-06-35.0'	09-28-92	<83	<50	<50	<50	<50	<50	<50
SB5-06-40.0'	09-29-92	<105	<50	<50	<50	<50	<50	<50
SB5-06-45.0'	09-29-92	<115	<50	<50	<50	<50	<50	<50
SB5-06-50.0'	09-29-92	<105	<50	<50	<50	<50	<50	<50
SB5-06-55.0'	09-29-92	<104	<50	<50	<50	<50	<50	58
SB5-06-60.0'	09-29-92	<101	<50	<50	<50	<50	<50	92
SB5-06-65.0'	09-29-92	<86	<50	<50	<50	<50	206	244
SB5-07								
SB5-07-10.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-07-15.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-07-20.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-07-25.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-07-30.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-07-34.5'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-07-40.0'	09-30-92	<50	<50	<50	<50	<50	<50	52
SB5-07-45.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-07-50.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50

Table 6-3

Site 5-BCP Remedial Investigation - Soil Field Screening Laboratory Results California Air National Guard - Fresno, California

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Sample Number	Date of Analysis	Results (µg/kg)[a]						
		1,1-DCE	trans 1,2-DCE	1,1-DCA	cis 1,2-DCE	1,2-DCA	TCE	PCE
SB5-07 (continued)								
SB5-07-55.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-07-60.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-07-65.0'	09-30-92	<50	<50	<50	<50	<50	<50	<50
SB5-08								
No detections in 16 samples								
SB5-09								
No detections in 16 samples								
SB5-10								
No detections in 15 samples								
SB5-11								
No detections in 17 samples								
SB5-12								
No detections in 9 samples								

[a]1,1-DCE - 1,1-Dichloroethene
trans-1,2-DCE - trans-1,2-Dichloroethene
1,1-DCA - 1,1-Dichloroethane
cis-1,2-DCE - cis-1,2-Dichloroethene
1,2-DCA - 1,2-Dichloroethane
TCE - Trichloroethene
PCE - Tetrachloroethene
[b]"<" signifies analyte was not detected at the indicated detection limit.

tions, it is concluded that TCE is likely present as a degradation product of PCE. Screening results show that Site 5-BCP is not currently contributing a measurable amount of contaminants, if any, to the groundwater system. The low concentrations and their distribution suggest that TCE and PCE are in an immobile state in the soil.

Groundwater data in the Site 5-BCP area shows the first occurrence of low concentrations of PCE on Base. Soil screening data also suggest that Site 5-BCP was at one time a likely contributor of PCE, and TCE to a minor extent, to the shallow groundwater system.

6.2.2 Site 5-BCP Confirmation Activity Results

Analytical data for the RI at Site 5-BCP have been summarized in tables on a sampled matrix basis. These summary tables contain only those compounds detected at some level. They do not include any tentatively identified compounds, any results qualified with a B* as a result of the blank correction process, or a compound that was not detected. Only those compounds that were detected in any sample are included on the tables. All of the confirmation soil samples were validated. A complete listing of each individual compound included in each analytical method is provided in Appendix I.

The soil sampling nomenclature begins with the Site 5 identification "SB5," followed by the predesignated boring number, such as -01 or -08, ending with the depth interval of the sample. Therefore, a sample labeled as SB5-02-50/50.5 is from a depth of 50 to 50.5 feet bgs from soil boring 2 at Site 5. The groundwater sampling nomenclature is similar, where the identification begins with "MW5," followed by the unique monitoring well number and the month/year of sampling (e.g., MW5-01-10/92).

6.2.2.1 Site 5-BCP Soil Sample Results

Confirmation soil samples collected for the RI were analyzed for VOCs, SVOCs, and TPH in the high boiling range (as diesel). A summary of all analyses for each sample is provided in Table 4-1 and each sample submitted for confirmation analysis and its rationale for selection is given in Table 4-2. A summary of results for those chemical compounds that were positively detected is provided in Table 6-4.

Volatile Organic Compounds. Only three VOCs were detected from the confirmation soil samples: acetone, methylene chloride, and TCE. Acetone was detected in borings SB5-11 and SB5-12 (total of three samples) ranging in concentration from 100 to 300 μg/kg (ppb). Methylene chloride was detected in only two soil samples from boring SB5-11 at concentra-

Table 6-4

Summary of Site 5-BCP Confirmation Soil Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Parameter Type	Units	Result	Lab Qual	Valid Qual	Sample Date
SB5-11-85.5/86.0	Acetone	VOC	µg/kg	220	BD	J	10/13/92
SB5-11-85/85.5	Acetone	VOC	µg/kg	300	B	J	10/13/92
SB5-12-80.5/81.0	Acetone	VOC	µg/kg	100	B		10/15/92
SB5-01-30.5/31.0	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	70	J	J	10/2/92
SB5-01-41.0/41.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	870			10/2/92
SB5-02-41.0/41.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	41	J		9/29/92
SB5-02-64.0/64.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	52	J		9/29/92
SB5-02-72.5/73.0	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	2200			9/29/92
SB5-03-19.0/19.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	60	J	J	9/24/92
SB5-03-34.0/34.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	87	J	J	9/24/92
SB5-03-64.0/64.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	66	J	J	9/24/92
SB5-03-9.0/9.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	96	J	J	9/24/92
SB5-04-29.5/30.0	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	6200			9/28/92
SB5-04-59.0/59.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	6100			9/28/92
SB5-05-29.0/29.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	55	J		9/23/92
SB5-07-17.0/17.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	260	J	J	9/24/92
SB5-07-29.0/29.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	150	J	J	9/24/92
SB5-07-44.0/44.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	190	J	J	9/24/92
SB5-07-64.0/64.5	bis(2-Ethylhexyl)phthalate	SVOC	µg/kg	81	J	J	9/24/92
SB5-04-59.0/59.5	Di-n-butyl phthalate	SVOC	µg/kg	47	J	J	9/28/92
SB5-05-22.0/22.5	Diethyl phthalate	SVOC	µg/kg	360	J		9/23/92
SB5-05-64.0/64.5	Diethyl phthalate	SVOC	µg/kg	530			9/23/92
SB5-06-24.0/24.5	Diethyl phthalate	SVOC	µg/kg	350	J		9/29/92
SB5-06-29.0/29.5	Diethyl phthalate	SVOC	µg/kg	1400			9/29/92
SB5-11-85.5/86.0	Methylene chloride	VOC	µg/kg	25	BD	J	10/13/92
SB5-11-85/85.5	Methylene chloride	VOC	µg/kg	85	B	J	10/13/92
SB5-10-85.5/86.0	TCE	VOC	µg/kg	5	J	J	10/12/92

tions of 25 and 85 µg/kg. Neither of these compounds is considered indicative of contamination associated with Site 5-BCP.

TCE was detected in one sample in background boring SB5-10 at an estimated concentration of 5 µg/kg at a depth of 85.5 to 86 feet. Its presence is likely due to diffusion into the deep soil from the water table.

Soil screening sample results (Section 6.2.1.3) showed TCE in approximately 20 percent and PCE in approximately 30 percent of samples collected from the five borings at the bottom of Site 5-BCP. These results conflict with confirmation sample results in that neither PCE nor TCE were detected from the same samples. This discrepancy is addressed in Section 6.2.3.

Semivolatile Organic Compounds. Three SVOCs were detected among the samples (Table 6-4). The most prevalent was bis-2-ethylhexyl phthalate, which was detected in several samples both within and outside Site 5-BCP. In one background boring (SB5-01), this compound was detected in two of the four samples collected from it, at concentrations ranging from 70 to 870 µg/kg. Bis-2-ethylhexyl phthalate was detected in four of the five borings at the bottom of Site 5-BCP (SB5-03, SB5-04, SB5-05, and SB5-07) at concentrations from 60 to 6,200 µg/kg. Several of the reported concentrations were estimated quantities less than the instrument detection limit, as noted by the "J" qualifier following the reported number.

Based on a number of factors, the validation process concluded that bis-2-ethylhexyl phthalate results may represent a sampling or analytical artifact, and is not likely to be site related:

- Experience with other sites shows that the presence of this compound without other companion contaminants is highly unusual, due to its general use as an additive chemical, most commonly as a plasticizer.
- bis-2-Ethylhexyl phthalate is soluble in water to only approximately 50 µg/kg (Montgomery and Welkom, 1990); therefore, the high concentrations detected at depth in the soil would be caused either by transport by dissolution in an organic solvent or by deliberate burial.
- If it were carried by a solvent, then the solvent also would have been detected at relatively high concentrations; no such solvents were found at high concentrations in either the VOC or SVOC analyses.
- If it were buried, it is unlikely that it would have been buried by itself. No site evidence suggests that any deep burial activities occurred.

- The detections of this compound exhibit no pattern with respect to depth or location.

- It could have been introduced by the field sampler's latex gloves, the sample tube's plastic end cap, or through contact with other plastic-related material (such as Tygon tubing) in the laboratory.

The compound di-n-butyl phthalate was detected only once, in sample SB5-04-59/59.5 at an estimated concentration of 47 µg/kg. Diethyl phthalate was detected in four samples: two in boring SB5-05 and two from boring SB5-06. Concentrations of diethyl phthalate were reported from 350 to 1,400 µg/kg; two of the reported values were estimated quantities less than the detection limit. This also is believed to be an artifact of either the sampling technique or the laboratory analysis, and not site related.

Total Petroleum Hydrocarbons (as Diesel). Results for the 41 confirmation samples collected in association with the Site 5-BCP soil sampling were all nondetect for the petroleum hydrocarbons analysis.

6.2.2.2 Site 5-BCP Groundwater Sample Results

A total of six monitoring wells were installed during the RI; however, only two of the wells were installed to directly monitor groundwater quality at Site 5-BCP. Groundwater samples from just these two newly installed wells for October 1992 through April 1993 will be discussed in this section. Results from the Base perimeter monitoring wells associated with the RI are discussed in Section 6.3. One other monitoring well that was installed during the SI in 1990 (MW2-01) is located hydraulically downgradient from Site 5-BCP. All three monitoring wells (MW5-01, MW5-02, and MW2-01) were sampled during the same time periods and their results are summarized in Table 6-5.

Groundwater samples from monitoring wells MW5-01 and MW5-02 were analyzed for VOCs, SVOCs, and pesticides/PCBs. The sample from MW2-01 was analyzed for VOC and for TPH in the high boiling (diesel) range. Only VOCs were detected in any of the samples from the three sampling events. Of the VOCs, only two were positively reported in the samples: TCE and PCE. In earlier reports (IT, 1992a, 1993c), chloroform was also reported as being detected in Site 5 groundwater samples. However, chloroform was removed from consideration as a result of blank correction. SVOCs, TPH, and pesticides/PCBs were not detected in any sample.

Table 6-5

Summary of Site 5-BCP Groundwater Sample Results
California Air National Guard - Fresno, California

Area ID	Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
Upgradient	MW5-01-10/92	PCE	µg/L	20			10/19/92
	MW5-01-01/93	PCE	µg/L	26			01/20/93
	MW5-01-04/93	PCE	µg/L	12			04/22/93
	MW5-01-10/92	TCE[a]	µg/L	8.7		N	10/19/92
	MW5-01-01/93	TCE[a]	µg/L	19			01/20/93
Downgradient	MW5-02-10/92	PCE	µg/L	4.1		NJ	10/19/92
	MW5-02-01/93	PCE	µg/L	3.5			01/20/93
	MW5-02-04/93	PCE	µg/L	3.3			04/22/93
	MW5-02-04/93Z	PCE	µg/L	3.1			04/22/93
	MW2-01-10/92	PCE	µg/L	25			10/22/92
	MW2-01-01/93	PCE	µg/L	23			01/19/93
	MW2-01-04/93	PCE	µg/L	15			04/19/93
	MW2-01-10/92	TCE[a]	µg/L	8.4			10/22/92
	MW2-01-01/93	TCE[a]	µg/L	7			01/19/93
	MW2-01-04/93	TCE[a]	µg/L	3			04/19/93

NOTES:

[a] Not a site-related chemical.

Samples with a "Z" suffix are field duplicate samples.

Volatile Organic Compounds. TCE was detected in MW5-01 for two of the three sampling events and in MW2-01 for all three events. TCE was detected at maximum concentrations of 19 μg/L in MW5-01 (upgradient) and 8.4 μg/L in MW2-01 during the three sampling events (Table 6-5). TCE was not detected in the closest downgradient well to Site 5-BCP, MW5-02. These concentrations of TCE are well below the average upgradient TCE concentration of 92 μg/L (Table 6-1). Soil screening samples did detect low concentrations of TCE (Table 6-3). It cannot, therefore, be ruled out that TCE was never introduced to the groundwater through Site 5-BCP. The data show, however, that any concentrations introduced were minor compared to the concentrations entering Base property from upgradient sources (Sections 6.1.2 and 6.3). Figure 6-1 shows the presence of TCE in the immediate vicinity of Site 5-BCP for the October 1992 sampling event. Data from the screening (grab) samples from borehole groundwater (Section 6.2.1.2) are integrated into this figure.

Figure 6-1 shows decreased TCE concentrations around Site 5-BCP. This phenomenon is likely due to dilution effects from infiltrating water. Infiltration water not containing TCE enters the groundwater flow system and dilutes the regional groundwater that contains TCE, thereby decreasing concentrations in groundwater around Site 5-BCP. This would account for the pattern observed. As also noted, TCE (and PCE) concentrations in the upgradient well, MW5-01, are higher than downgradient concentrations. Infiltrating water may also be responsible for this phenomenon, where the infiltration causes a local groundwater mound, or reverse hydraulic gradient. This would allow for a small amount of upgradient migration or diffusion of contaminants. It is also possible that less dilution is occurring at the MW5-01 location. Less infiltration water may reach the MW5-01 location (Figure 6-1) such that less dilution occurs and TCE concentrations are higher there than at downgradient locations.

It is also clear that the extent of dilution effects on regional groundwater is limited. A groundwater screening (grab) sample collected approximately 175 feet downgradient from Site 5-BCP (sample SB5-12) contained 100 μg/L TCE. TCE that is present at concentrations of 170 to 190 μg/L upgradient of Site 5-BCP appears to be diluted with infiltration water from the BCP that does not contain TCE such that concentrations approach nondetect values immediately around Site 5-BCP. Yet groundwater outside of the influence of infiltration from the BCP, such as at SB5-12, remains impacted by TCE at concentrations similar to those detected at upgradient locations, such as at MWBP-03 (Figure 6-1).

PCE was detected in all three monitoring wells. The site-specific upgradient well (MW5-01) had a maximum concentration of 26 μg/L. The downgradient wells, MW5-02 and MW2-01,

STARTING DATE: 10/13/95	DATE LAST REV.: 4/08/96	DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.063
DRAWN BY: D.BILLINGSLEY	DRAWN BY: D.BILLINGSLEY	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

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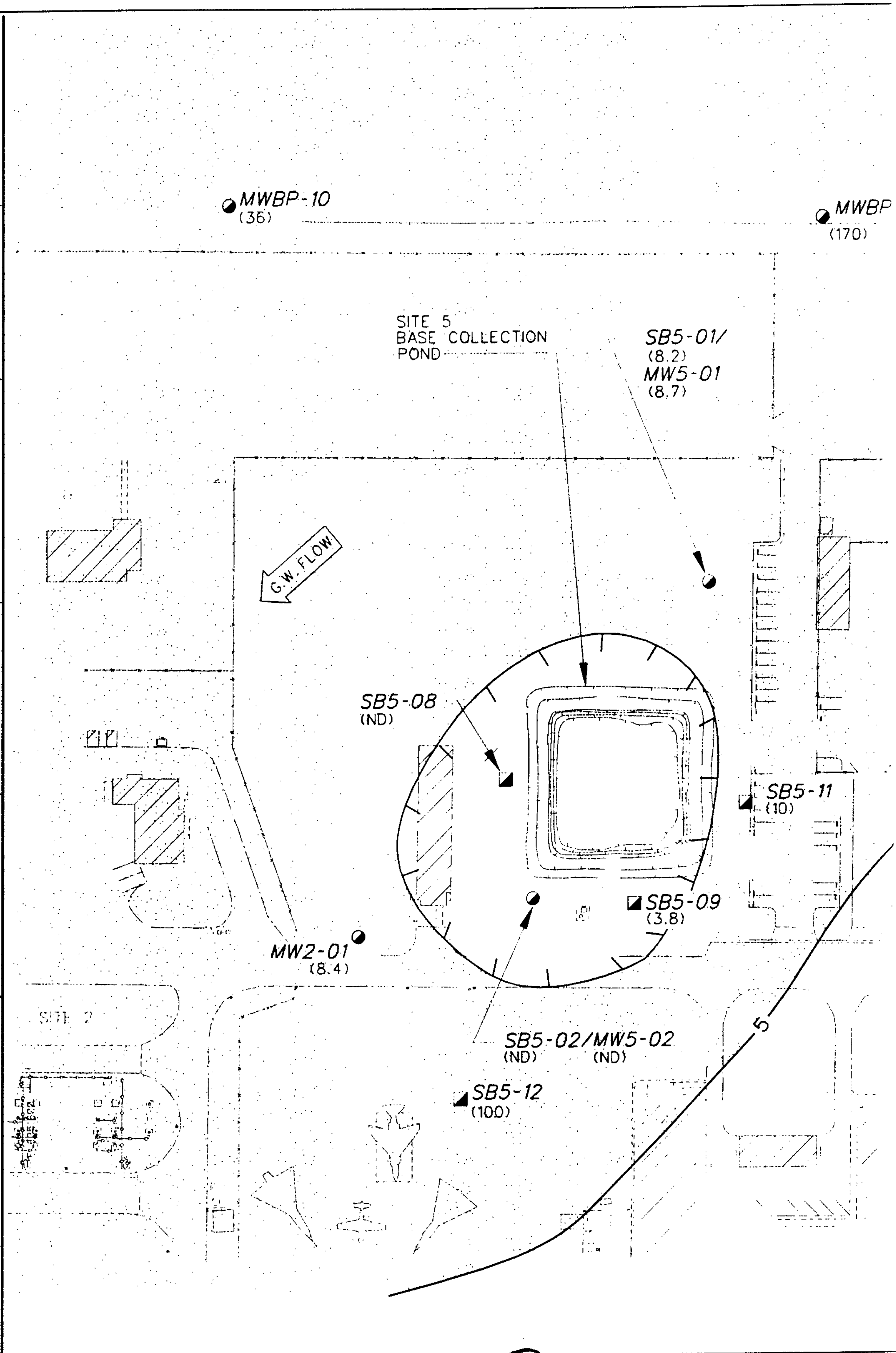
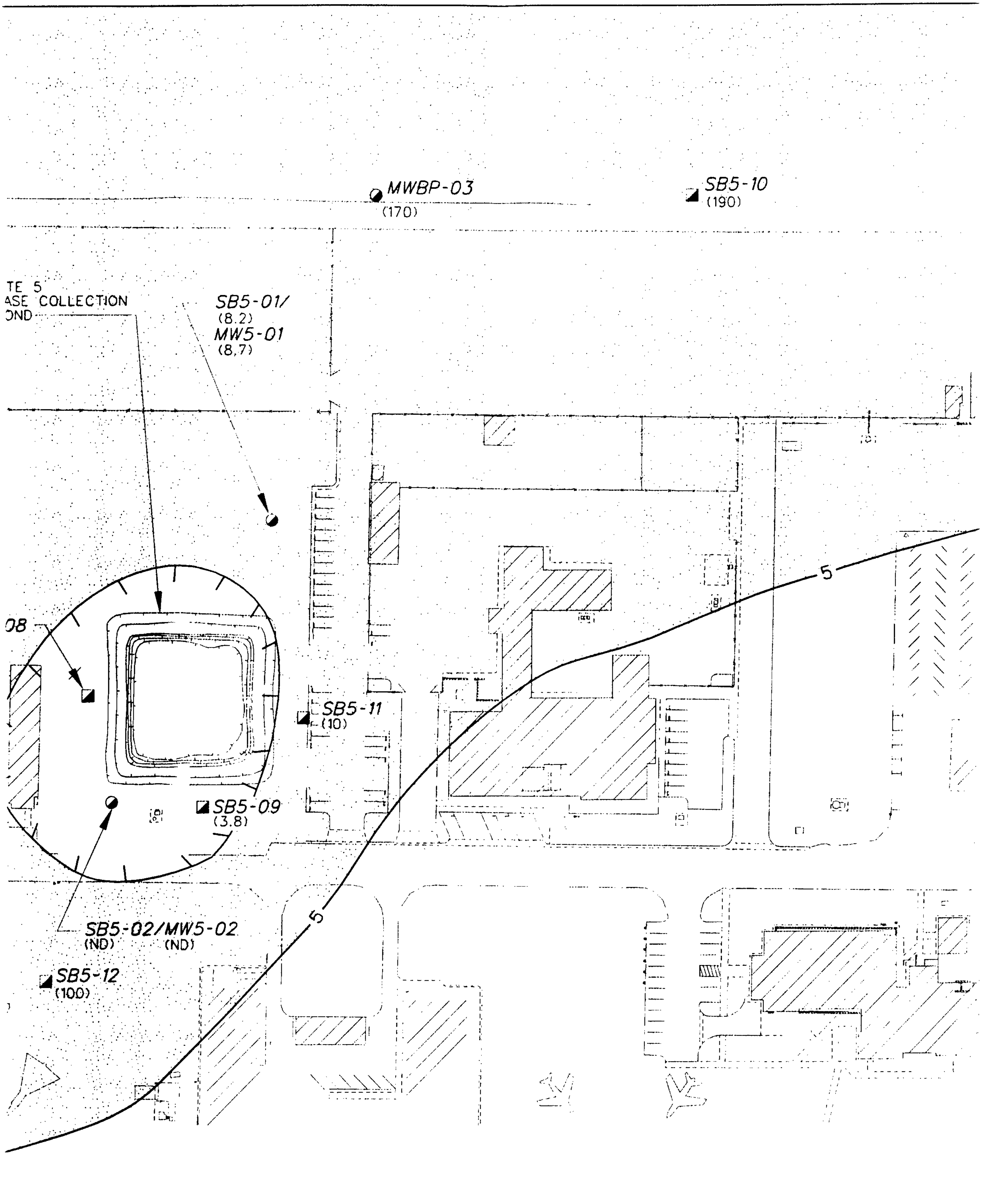
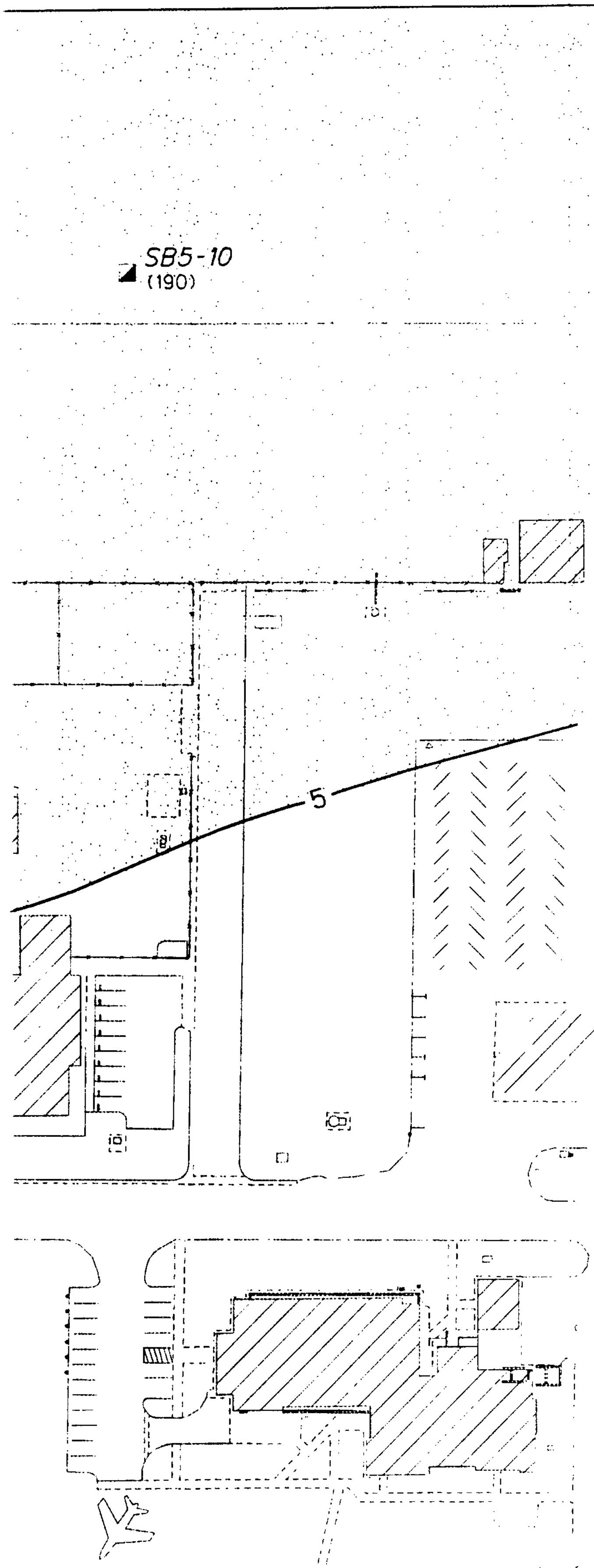



MWBP-03
(170)
SB5-10
(190)
TE 5
ASE COLLECTION
OND
SB5-01/
(8.2)
MW5-01
(8.7)
5
08
SB5-11
(10)
SB5-09
(3.8)
5
SB5-02/MW5-02
(ND) (ND)
SB5-12
(100)



LEGEND:

MWBP-03 (170)	WATER TABLE MONITORING WELL WITH 10/92 TCE CONCENTRATION IN uG/L
SB5-10 (190)	BOREHOLE GROUNDWATER SCREENING SAMPLE WITH TCE CONCENTRATION IN uG/L
(ND)	NOT DETECTED
5	CALIFORNIA DRINKING WATER STANDARD FOR TCE
G.W. FLOW	GROUNDWATER FLOW DIRECTION
	TCE PLUME AREA

SCALE:

0 100 200 FEET

FIGURE 6-1

PRESENCE OF TCE AT THE WATER TABLE IN THE VICINITY OF SITE NO. 5, OCTOBER 1992

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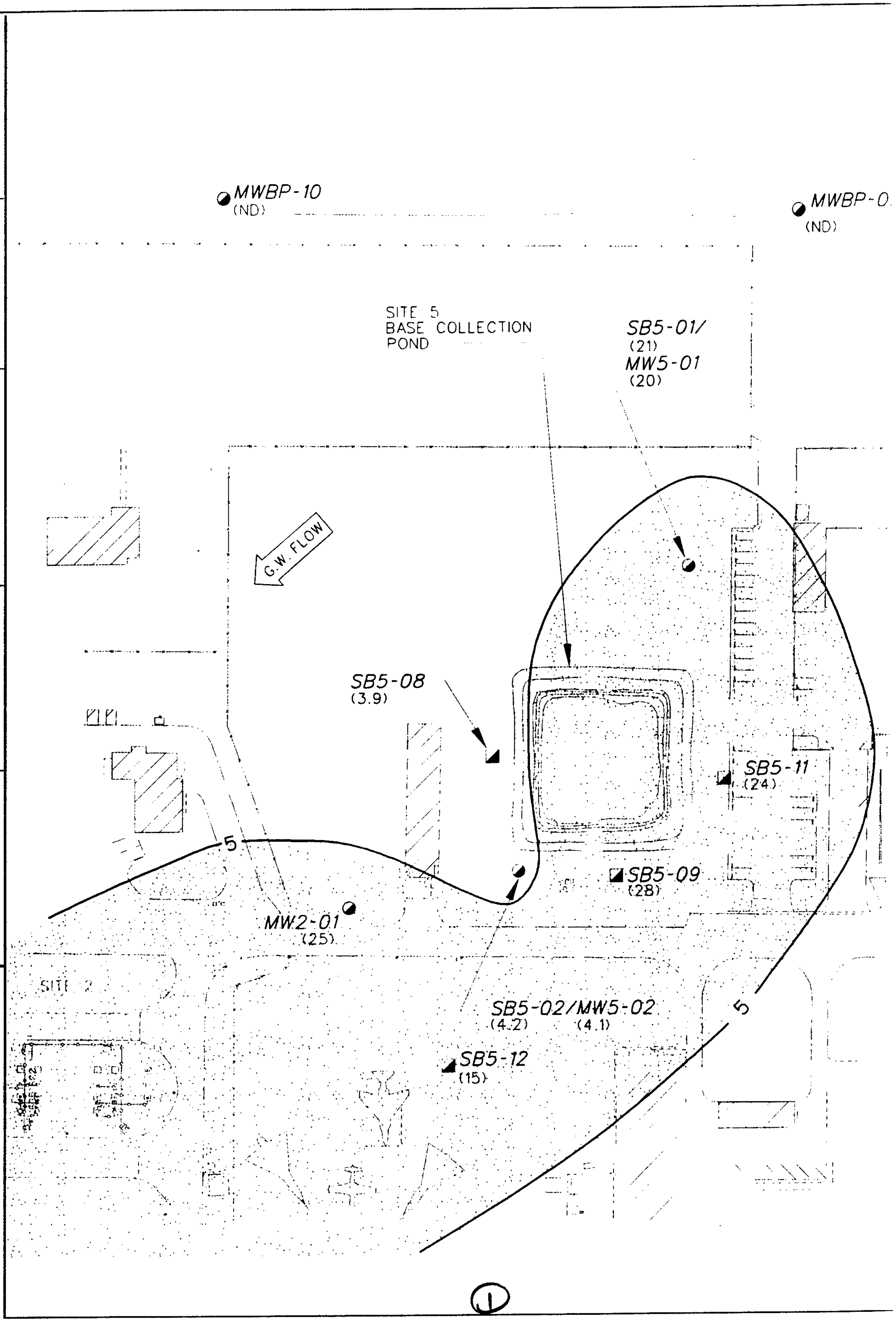
reported maximum concentrations of 4.1 and 25 μg/L, respectively (Table 6-5). PCE has not been detected in upgradient wells across the western portion of the Base. It would be expected that if Site 5-BCP was the source for PCE groundwater contamination that MW5-01 would not have similar average concentrations as the site-specific downgradient wells. As previously discussed, with the low hydraulic gradient in the area (0.003) and the local recharge to the water table afforded through Site 5-BCP (before it was filled in), upgradient migration via advective and diffusive forces is likely to occur. It is also possible that the combination of the local recharge and low hydraulic gradient may cause a local stagnation area where the eventual downgradient migration is slowed. This may also allow for increased vertical (downward) migration through the uppermost saturated sediments. Figure 6-2 shows the distribution of PCE at the water table for the October 1992 sampling event that also incorporates results from the borehole groundwater screening (grab) samples.

PCE concentrations over time show either stability or a slightly decreasing trend. Concentrations of PCE at each Site 5-BCP well are lower in the last sampling event (April 1993) than the first sampling event (October 1992). This suggests no active source area for PCE contamination exists.

6.2.3 Discussion

Comparison of Screening to Confirmation Soil Sample Results. Sample results for the Site 5-BCP screening analysis versus the fixed-base laboratory analysis for VOCs are in conflict, as presented in Sections 6.2.1.3 and 6.2.2.1. Screening results showed TCE in approximately 20 percent of the samples and PCE in approximately 30 percent of the samples from the five borings located at the bottom of Site 5-BCP. The laboratory results showed no detections whatsoever from the samples collected in Site 5-BCP.

It has been well documented that even when prescribed sample preservation techniques are followed and when analyses are performed within the prescribed time frame (holding time), significant losses of VOCs can occur. Mechanisms responsible for the losses include volatilization, biodegradation, and chemical transformation (Siegrist and van Ee, 1994; Hewitt, et al., 1995; Lewis, et al., 1991; Siegrist and Jenssen, 1990; Maskarinec, et al., 1992). As Siegrist and van Ee state (1994): "Loss of volatiles begins from the time a sample is collected to the time it is analyzed....A sample that is analyzed soon and with little disruption is more likely to be representative of actual site conditions."



STARTING DATE: 10/13/95 | DATE LAST REV.: | DRAFT. CHCK. BY: | INITIATOR: | DWG. NO.:
DRAWN BY: D.BILLINGSLEY | DRAWN BY: | ENGR. CHCK. BY: S. LOGAN | PROJ. MGR.: | PROJ. NO.: 409724

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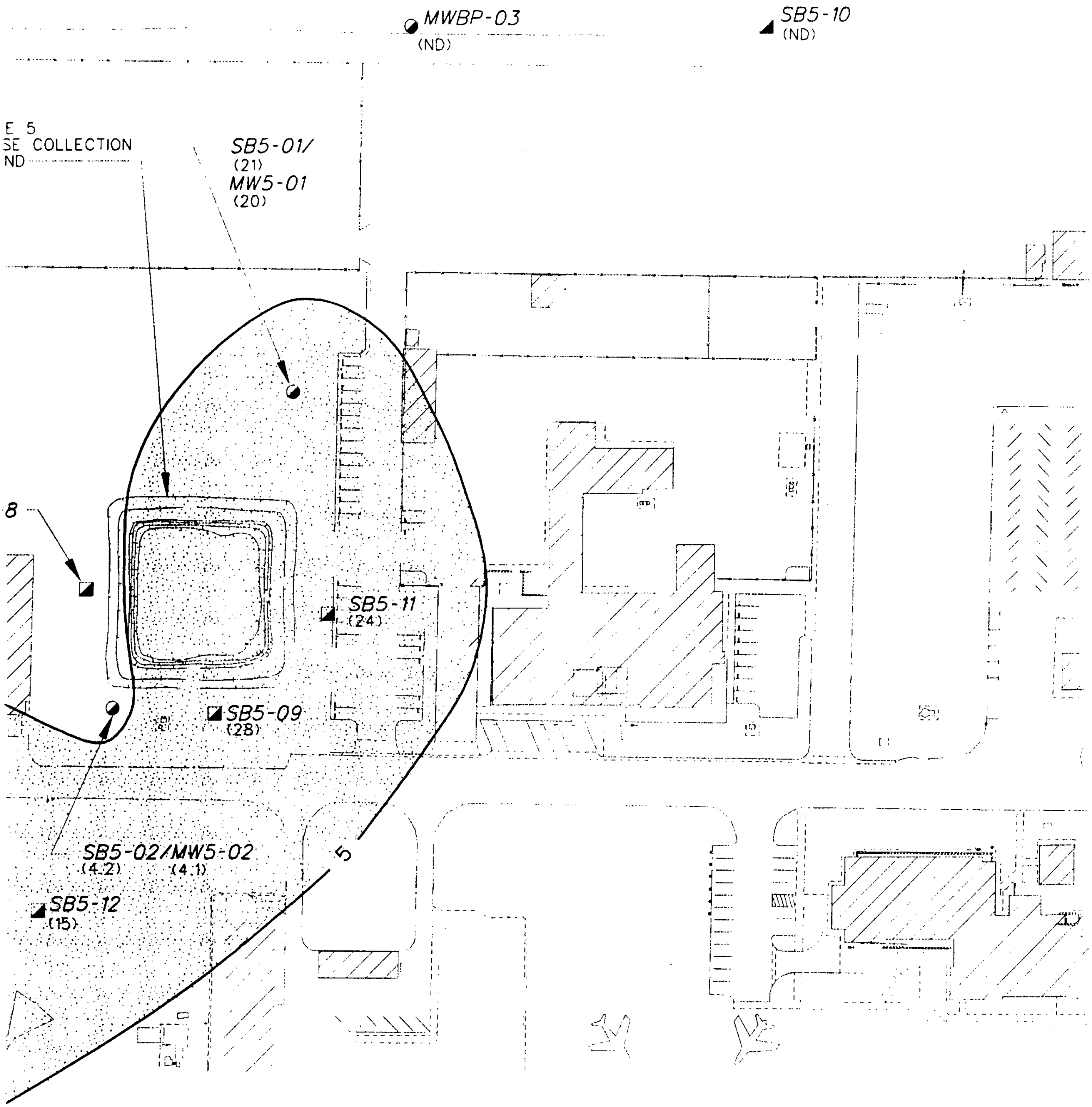
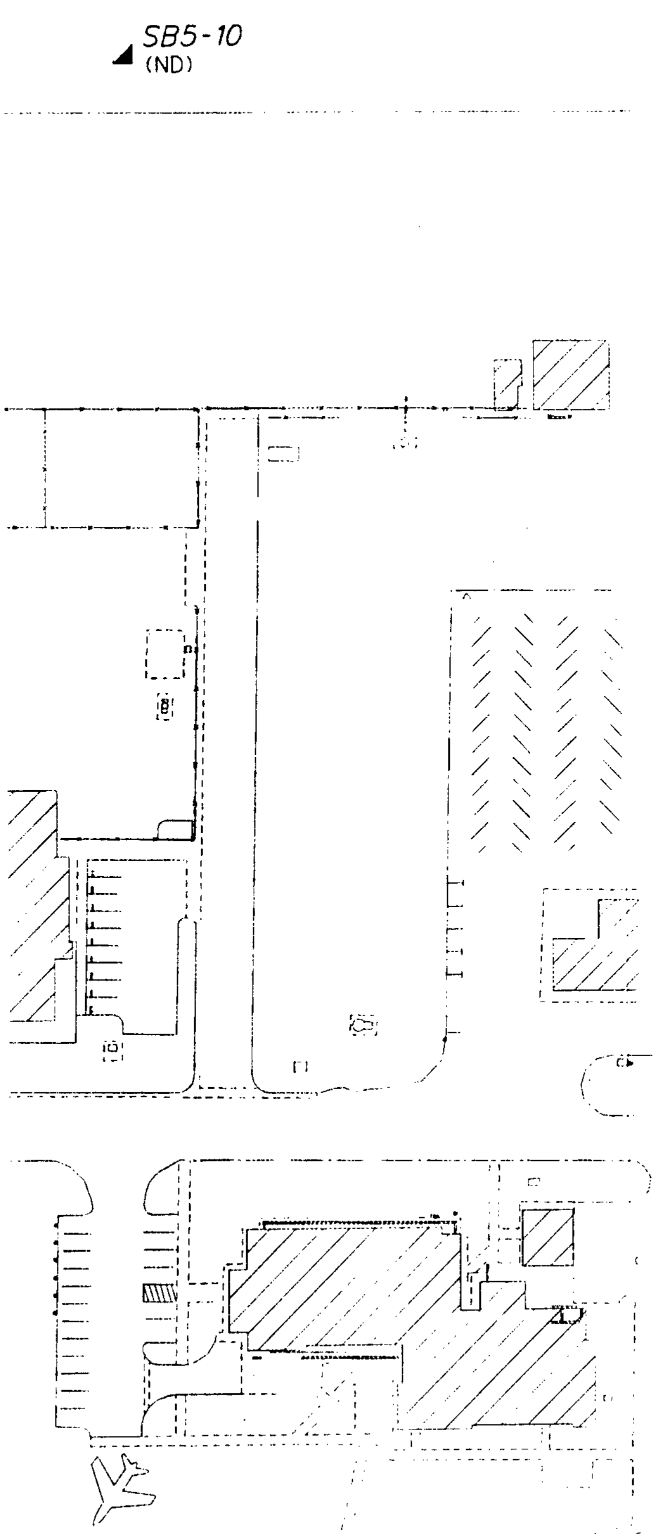


MWBP-03
(ND)
SB5-10
(ND)
E 5
SE COLLECTION
ND
SB5-01/
(21)
MW5-01
(20)
8
SB5-11
(24)
SB5-09
(28)
SB5-02/MW5-02
(4.2)
(4.1)
SB5-12
(15)
5

2



LEGEND:

MW2-01 (25)	WATER TABLE MONITORING WELL WITH 10/92 PCE CONCENTRATION IN uG/L
SB5-11 (24)	BOREHOLE GROUNDWATER SCREENING SAMPLE WITH PCE CONCENTRATION IN uG/L
(ND)	NOT DETECTED
5	CALIFORNIA DRINKING WATER STANDARD FOR PCE
G.W. FLOW	GROUNDWATER FLOW DIRECTION
	PCE PLUME AREA

SCALE:

0 100 200 FEET

FIGURE 6-2

PRESENCE OF PCE AT THE WATER TABLE IN THE VICINITY OF SITE NO. 5, OCTOBER 1992

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This appears to be the case for the discrepancy observed from the two sets of data (screening versus confirmation). While screening data are not able to be validated to current standards, data provided from the field GC are considered to be more indicative of subsurface conditions. In this case, laboratory results, while validated, do not reliably depict the profile of chemical constituents in soil at Site 5-BCP. For the purpose of the risk assessment (Chapter 9.0), both screening and confirmation results were used in quantifying potential exposure risks.

The assertion that screening sample results are more representative of subsurface conditions is supported by the groundwater sample results at Site 5-BCP. Both the borehole groundwater screening samples and monitoring well confirmation samples reported low concentrations of PCE in groundwater beneath Site 5, implicating the BCP as the source area for PCE. The presence of PCE in the soil screening samples correlate with the groundwater sample results.

6.3 Shallow Groundwater Sample Results

Shallow groundwater results refers to sampling of water table monitoring wells over the history of the project. A total of six groundwater sampling events have occurred between November 1990 and April 1993, as listed in Table 4-4, and include SI and quarterly sampling activities. Not all of the shallow wells have been sampled during all six events. Table 6-6 provides a summary of positive detections for all of the upgradient and downgradient perimeter wells. Detections summarized in Table 6-6 will differ from data summaries presented in earlier reports due to the removal of some detections as a result of the blank correction process. Groundwater sample results for Site 2 wells are also presented here to provide supplemental information on the extent of the groundwater plumes. Groundwater sampling information for the SI sites is presented in the Supplemental SI report (IT, 1996b) and the April 1993 quarterly groundwater monitoring report (IT, 1993c).

6.3.1 Site 2 Groundwater

Three monitoring wells have been sampled for VOCs and TPH-d six times each. Only the VOC results will be discussed here.

As listed in Table 6-6, TCE and PCE comprise the majority of compounds detected in groundwater samples. Chloroform was reported in two samples and trans-1,2-DCE was reported in one sample. None of the VOCs detected are site-related; all of the reported compounds are present in upgradient groundwater and/or are not associated with POL facilities.

Table 6-6

Summary of Shallow Monitoring Well Groundwater Sample Results
California Air National Guard - Fresno, California

Area ID	Sample ID	Parameter	Units	Result	Lab Qual	Valid Qual	Sample Date
Site 2	MW2-01-11/90	PCE	µg/L	47	J		11/09/90
	MW2-01-02/91	PCE	µg/L	52	J	J	02/06/91
	MW2-01-06/92	PCE	µg/L	38			06/28/92
	MW2-01-10/92	PCE	µg/L	25			10/22/92
	MW2-01-01/93	PCE	µg/L	23			01/19/93
	MW2-01-04/93	PCE	µg/L	15			04/19/93
	MW2-01-11/90	TCE	µg/L	27	J		11/09/90
	MW2-01-02/91	TCE	µg/L	20			02/06/91
	MW2-01-06/92	TCE	µg/L	6			06/28/92
	MW2-01-10/92	TCE	µg/L	8.4			10/22/92
	MW2-01-01/93	TCE	µg/L	7			01/19/93
	MW2-01-04/93	TCE	µg/L	3			04/19/93
	MW2-02-02/91	Chloroform	µg/L	1.4			02/06/91
	MW2-02-11/90	PCE	µg/L	100	J		11/09/90
	MW2-02-02/91	PCE	µg/L	85	J	J	02/06/91
	MW2-02-06/92	PCE	µg/L	22			06/28/92
	MW2-02-10/92	PCE	µg/L	45			10/21/92
	MW2-02-01/93	PCE	µg/L	69			01/19/93
	MW2-02-04/93	PCE	µg/L	43			04/19/93
	MW2-02-10/92	trans-1,2-DCE	µg/L	7.1			10/21/92
	MW2-02-11/90	TCE	µg/L	21	J		11/09/90
	MW2-02-02/91	TCE	µg/L	9.5			02/06/91
	MW2-02-06/92	TCE	µg/L	3.5			06/28/92
	MW2-02-01/93	TCE	µg/L	6			01/19/93
	MW2-02-04/93	TCE	µg/L	5.9			04/19/93
	MW2-03-02/91	Chloroform	µg/L	1.3			02/06/91
	MW2-03-11/90	High Boiling Fuel Hydrocarbons	µg/L	430			11/09/90
	MW2-03-11/90	PCE	µg/L	41	J		11/09/90
	MW2-03-02/91	PCE	µg/L	80	J	J	02/06/91
	MW2-03-06/92	PCE	µg/L	30			06/28/92
	MW2-03-10/92	PCE	µg/L	44			10/21/92
	MW2-03-01/93	PCE	µg/L	46			01/19/93
	MW2-03-04/93	PCE	µg/L	33			04/19/93
	MW2-03-04/93Z	PCE	µg/L	33			04/19/93
	MW2-03-11/90	TCE	µg/L	9.1	J		11/09/90
	MW2-03-02/91	TCE	µg/L	11			02/06/91
	MW2-03-06/92	TCE	µg/L	5.1			06/28/92
	MW2-03-10/92	TCE	µg/L	6.6			10/21/92
	MW2-03-01/93	TCE	µg/L	6.5			01/19/93
	MW2-03-04/93	TCE	µg/L	5.8			04/19/93
	MW2-03-04/93Z	TCE	µg/L	5.7			04/19/93

Table 6-6

Summary of Shallow Monitoring Well Groundwater Sample Results
California Air National Guard - Fresno, California

Area ID	Sample ID	Parameter	Units	Result	Lab Qual	Valid Qual	Sample Date
Site 3 and Base background	MW3-01A-11/90	Chrysene	µg/L	6	J		11/14/90
	BMW-1-11/90	bis(2-Ethylhexyl)phthalate	µg/L	5	J		11/14/90
	BMW-1-11/90	Chrysene	µg/L	5	J		11/14/90
	BMW-2	No positive detections in 5 samples.					
Site 5	MW5-01-10/92	PCE	µg/L	20			10/19/92
	MW5-01-01/93	PCE	µg/L	26			01/20/93
	MW5-01-04/93	PCE	µg/L	12			04/22/93
	MW5-01-10/92	TCE	µg/L	8.7		N	10/19/92
	MW5-01-01/93	TCE	µg/L	19			01/20/93
	MW5-02-10/92	PCE	µg/L	4.1		NJ	10/19/92
	MW5-02-01/93	PCE	µg/L	3.5			01/20/93
	MW5-02-04/93	PCE	µg/L	3.3			04/22/93
	MW5-02-04/93Z	PCE	µg/L	3.1			04/22/93
Base Perimeter - Upgradient	MWBP-01-11/90	1,2-DCP	µg/L	3.3	J		11/09/90
	MWBP-01-02/91	1,2-DCP	µg/L	4			02/12/91
	MWBP-01-10/92	1,2-DCP	µg/L	2.5			10/20/92
	MWBP-01-01/93	1,2-DCP	µg/L	4.6			01/20/93
	MWBP-01-04/93	1,2-DCP	µg/L	3.6			04/20/93
	MWBP-01-11/90	TCE	µg/L	7.7	J		11/09/90
	MWBP-01-02/91	TCE	µg/L	9.8			02/12/91
	MWBP-01-06/92	TCE	µg/L	9.9			06/28/92
	MWBP-01-10/92	TCE	µg/L	8.1			10/20/92
	MWBP-01-01/93	TCE	µg/L	11			01/20/93
	MWBP-01-04/93	TCE	µg/L	9.7			04/20/93
	MWBP-02-11/90	1,2-DCP	µg/L	4.4	J		11/08/90
	MWBP-02-02/91	1,2-DCP	µg/L	5.1			02/12/91
	MWBP-02-07/92	1,2-DCP	µg/L	2.6			07/01/92
	MWBP-02-10/92	1,2-DCP	µg/L	2.7			10/20/92
	MWBP-02-01/93Z	1,2-DCP	µg/L	5.2			01/20/93
	MWBP-02-04/93	1,2-DCP	µg/L	2.9			04/20/93
	MWBP-02-11/90	Carbon tetrachloride	µg/L	0.6	J		11/08/90
	MWBP-02-11/90	TCE	µg/L	28	J		11/08/90
	MWBP-02-02/91	TCE	µg/L	37			02/12/91
	MWBP-02-07/92	TCE	µg/L	32			07/01/92
	MWBP-02-10/92	TCE	µg/L	45			10/20/92
	MWBP-02-01/93	TCE	µg/L	49			01/20/93
	MWBP-02-01/93Z	TCE	µg/L	48			01/20/93
	MWBP-02-04/93	TCE	µg/L	30			04/20/93

Table 6-6

Summary of Shallow Monitoring Well Groundwater Sample Results
California Air National Guard - Fresno, California

(Page 3 of 4)

Area ID	Sample ID	Parameter	Units	Result	Lab Qual	Valid Qual	Sample Date
Base Perimeter - Upgradient (continued)	MWBP-03-11/90	1,2-DCP	µg/L	6.9	J		11/08/90
	MWBP-03-02/91	1,2-DCP	µg/L	4.8			02/12/91
	MWBP-03-6/92	1,2-DCP	µg/L	5			06/30/92
	MWBP-03-6/92Z	1,2-DCP	µg/L	5			06/30/92
	MWBP-03-10/92	1,2-DCP	µg/L	4.9			10/20/92
	MWBP-03-01/93	1,2-DCP	µg/L	13			01/20/93
	MWBP-03-04/93	1,2-DCP	µg/L	7			04/20/93
	MWBP-03-11/90	Carbon tetrachloride	µg/L	0.8	J		11/08/90
	MWBP-03-6/92	Di-n-butyl phthalate	µg/L	2	BJ		06/30/92
	MWBP-03-6/92Z	Diethyl phthalate	µg/L	2	J		06/30/92
	MWBP-03-11/90	TCE	µg/L	140	J		11/08/90
	MWBP-03-02/91	TCE	µg/L	210	D		02/12/91
	MWBP-03-6/92	TCE	µg/L	140			06/30/92
	MWBP-03-6/92Z	TCE	µg/L	140			06/30/92
	MWBP-03-10/92	TCE	µg/L	170			10/20/92
	MWBP-03-01/93	TCE	µg/L	130			01/20/93
	MWBP-03-04/93	TCE	µg/L	160			04/20/93
	MWBP-04-11/90	1,2-DCP	µg/L	1.1	J		11/08/90
	MWBP-04-6/92	bis(2-Ethylhexyl)phthalate	µg/L	0.5	BJ		06/30/92
	MWBP-04-6/92	Di-n-butyl phthalate	µg/L	0.9	BJ		06/30/92
	MWBP-04-6/92	Diethyl phthalate	µg/L	0.7	J		06/30/92
	MWBP-04-11/90	TCE	µg/L	3.3	J		11/08/90
	MWBP-04-02/91	TCE	µg/L	3.7			02/12/91
	MWBP-04-6/92	TCE	µg/L	2			06/30/92
	MWBP-04-04/93	TCE	µg/L	2.6			04/20/93
	MWBP-09-09/92	TCE	µg/L	450			09/21/92
	MWBP-09-01/93	TCE	µg/L	520			01/21/93
	MWBP-09-04/93	TCE	µg/L	450			04/21/93
	MWBP-10-10/92	1,2-DCP	µg/L	2.4			10/19/92
	MWBP-10-01/93	1,2-DCP	µg/L	2.5			01/21/93
	MWBP-10-04/93	1,2-DCP	µg/L	2.9			04/21/93
	MWBP-10-10/92	TCE	µg/L	36		J	10/19/92
	MWBP-10-01/93	TCE	µg/L	29			01/21/93
	MWBP-10-04/93	TCE	µg/L	30			04/21/93
Base Perimeter - Downgradient	MWBP-05-10/92	cis-1,2-DCE	µg/L	13			10/21/92
	MWBP-05-11/90	PCE	µg/L	110			11/12/90
	MWBP-05-02/91	PCE	µg/L	110	D		02/11/91
	MWBP-05-07/92	PCE	µg/L	60			07/01/92
	MWBP-05-07/92Z	PCE	µg/L	69			07/01/92
	MWBP-05-10/92	PCE	µg/L	82			10/21/92
	MWBP-05-01/93	PCE	µg/L	50			01/21/93
	MWBP-05-04/93	PCE	µg/L	57			04/20/93
	MWBP-05-11/90	TCE	µg/L	35			11/12/90
	MWBP-05-02/91	TCE	µg/L	29			02/11/91
	MWBP-05-07/92	TCE	µg/L	35			07/01/92

Table 6-6

Summary of Shallow Monitoring Well Groundwater Sample Results
California Air National Guard - Fresno, California

Area ID	Sample ID	Parameter	Units	Result	Lab Qual	Valid Qual	Sample Date
Base Perimeter - Downgradient (continued)	MWBP-05-07/92Z	TCE	µg/L	41			07/01/92
	MWBP-05-10/92	TCE	µg/L	39			10/21/92
	MWBP-05-01/93	TCE	µg/L	37			01/21/93
	MWBP-05-04/93	TCE	µg/L	31			04/20/93
	MWBP-06A-11/90	1,2-DCP	µg/L	0.5	J		11/12/90
	MWBP-06A-02/91	bis(2-Ethylhexyl)phthalate	µg/L	2	J		02/11/91
	MWBP-06A-11/90	Chrysene	µg/L	3	J		11/12/90
	MWBP-06A-11/90	PCE	µg/L	1.7	J		11/12/90
	MWBP-06A-02/91	PCE	µg/L	5.4			02/11/91
	MWBP-06A-07/92	PCE	µg/L	5			07/01/92
	MWBP-06A-10/92	PCE	µg/L	3.2			10/20/92
	MWBP-06A-01/93	PCE	µg/L	6.2			01/21/93
	MWBP-06A-01/93Z	PCE	µg/L	6			01/21/93
	MWBP-06A-04/93	PCE	µg/L	5.8			04/20/93
	MWBP-06A-11/90	TCE	µg/L	0.7	J		11/12/90
	MWBP-07	No positive detections in 6 samples.					
	MWBP-08-02/91	bis(2-Ethylhexyl)phthalate	µg/L	7	J		02/08/91
	MWBP-08-11/90	Chrysene	µg/L	6	J		11/12/90
	MWBP-08-11/90	PCE	µg/L	1.2	J		11/12/90
	MWBP-08-02/91	PCE	µg/L	1			02/08/91
	MWBP-08-07/92	PCE	µg/L	3			07/01/92
	MWBP-08-10/92	PCE	µg/L	2			10/20/92
	MWBP-11-09/92	1,2-DCP	µg/L	2.4			09/21/92
	MWBP-11-01/93	1,2-DCP	µg/L	4.1			01/20/93
	MWBP-11-09/92	TCE	µg/L	16			09/21/92
	MWBP-11-01/93	TCE	µg/L	27			01/20/93
	MWBP-11-04/93	TCE	µg/L	7			04/22/93
	MWBP-11-04/93Z	TCE	µg/L	6.4			04/22/93
	MWBP-12-10/92	PCE	µg/L	1.5		J	10/19/92
	MWBP-12-01/93	TCE	µg/L	12			01/20/93
	MWBP-12-04/93	TCE	µg/L	5.5			04/22/93

NOTES:
Samples with a "Z" suffix are field duplicate samples.

PCE concentrations in Site 2 monitoring wells have shown a decreasing trend over time. Concentrations are lower in the last sampling event than in the first sampling event (November 1990). As discussed in Section 6.2.2.2, this suggests that there is no active source area for PCE that contributes PCE to the groundwater system.

6.3.2 Upgradient Base Perimeter Groundwater

Six shallow monitoring wells exist along a hydraulically upgradient position (Figure 4-4): MWBP-01, MWBP-02, MWBP-03, MWBP-04, MWBP-09 and MWBP-10. Table 4-4 lists the types and numbers of analyses performed during each sampling event. Table 6-6 summarizes the positive detections for each sample collected. Upgradient Base perimeter concentration ranges are presented in Table 6-1.

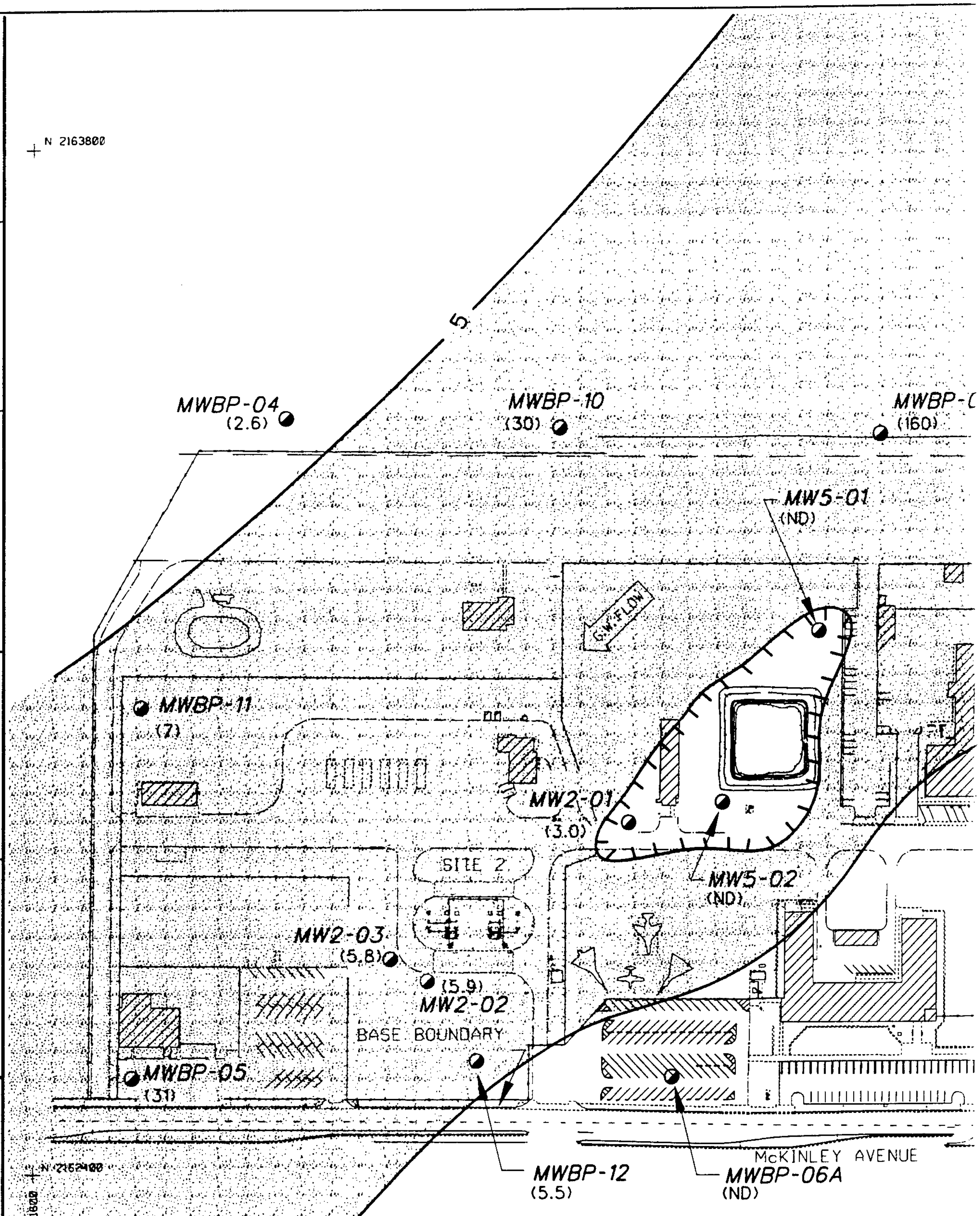
As is evident from Table 6-1, TCE and 1,2-DCP are present in upgradient groundwater and TCE is present at relatively significant concentrations. Carbon tetrachloride is the only other VOC detected in upgradient groundwater. The presence of an upgradient source area for TCE has been identified in investigations being conducted across FAT (ERM, 1992; 1994), as shown in Figure 2-3. TCE concentrations in upgradient wells are relatively consistent from one sampling round to the next. Only along the western edge of the TCE plume (wells MWBP-04 and MWBP-10) have concentrations decreased slightly during the sampling program. At the other areas of the plume, TCE levels have remained stable. Figure 6-3 shows the approximate boundaries of the TCE plume at the water table for the latest available data. Plume boundaries are defined as the maximum contaminant level (MCL) for TCE (5 µg/L).

Sporadic detections of various phthalates (SVOCs) are listed in Table 6-6. Their presence is attributed to either sample handling in the field (e.g., latex gloves) or to peripheral laboratory contamination (e.g., plastic tubing).

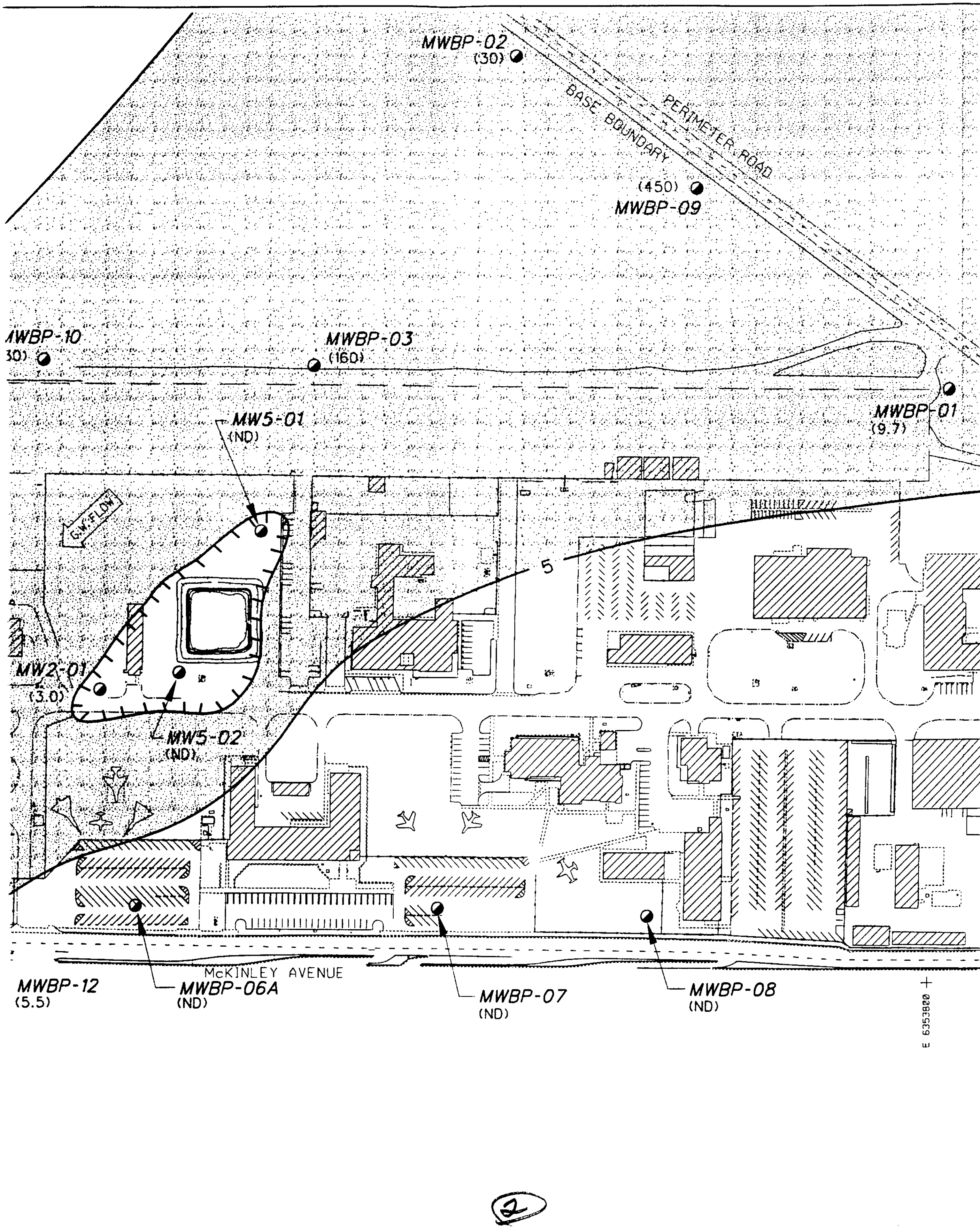
6.3.3 Downgradient Base Perimeter Groundwater

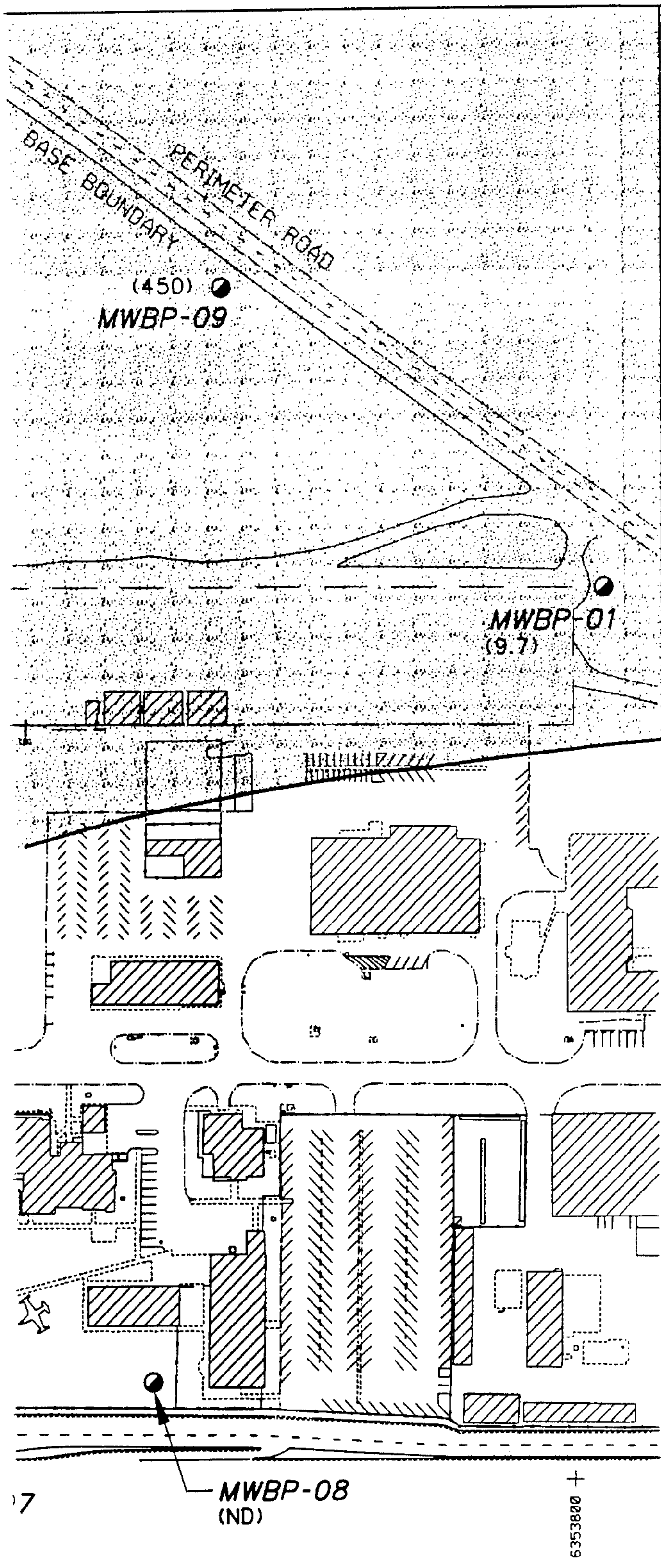
Six shallow monitoring wells exist along a hydraulically downgradient position (Figure 4-4): MWBP-05, MWBP-06A, MWBP-07, MWBP-08, MWBP-11 and MWBP-12. Table 4-4 lists the types and numbers of analyses performed during each sampling event. Table 6-6 summarizes the positive detections for each sample collected. Table 6-7 presents a summary of detected concentrations of the downgradient sample results.

STARTING DATE:10/13/95	DATE LAST REV.:	DRAFT. CHCK. BY:C.TUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.062
DRAWN BY:D.BILLINGSLEY	DRAWN BY:	ENGR. CHCK. BY:S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724



409724ES.062 09:18:49 JAN 2, 1997 DAA


MWBP-02
(30)
BASE BOUNDARY
PERIMETER ROAD
(450)
MWBP-09
MWBP-10
MWBP-03
(160)
MWBP-01
(9.7)
MW5-01
(ND)
G.W. FLOW
5
MW2-01
(3.0)
MW5-02
(ND)
McKINLEY AVENUE
MWBP-12
(5.5)
MWBP-06A
(ND)
MWBP-07
(ND)
MWBP-08
(ND)
E 6353800



LEGEND:

MWBP-03 (160)	MONITORING WELL WITH PCE CONCENTRATION IN uG/L
(ND)	NOT DETECTED
5	CALIFORNIA DRINKING WATER STANDARD FOR PCE
G.W. FLOW	GROUNDWATER FLOW DIRECTION
	TCE PLUME AREA

SCALE:

0 200 400 FEET

FIGURE 6-3

PRESENCE OF TCE AT THE WATER TABLE FOR SAMPLES COLLECTED IN APRIL 1993

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FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

IT INTERNATIONAL TECHNOLOGY CORPORATION

3

Table 6-7

Summary of Detections, Downgradient Base Perimeter Monitoring Wells California Air National Guard - Fresno, California

Upgradient Well ID	Frequency of Detections	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)	Upgradient Perimeter Well Range	
TCE					
MWBP-05	6/6	29	39		
MWBP-06A	1/6	0.7	0.7		
MWBP-07	0/6	--	--		
MWBP-08	0/6	--	--		
MWBP-11	3/3	7	27		
MWBP-12	2/3	5.5	12		
Sum	12/30		39	28/30	520
1,2-DCP					
MWBP-05	0/6	--	--		
MWBP-06A	1/6	0.5	0.5		
MWBP-07	0/6	--	--		
MWBP-08	0/6	--	--		
MWBP-11	2/3	2.4	4.1		
MWBP-12	0/3	--	--		
Sum	3/30		4.1	21/30	5.2
PCE					
MWBP-05	6/6	50	110		
MWBP-06A	6/6	1.7	6.2		
MWBP-07	0/6	--	--		
MWBP-08	4/6	1	3		
MWBP-11	0/3	--	--		
MWBP-12	1/3	1.5	1.5		
Sum	17/30		110	0/30	--

VOCs reported in downgradient monitoring wells include TCE, PCE, 1,2-DCP and cis-1,2-DCE. 1,2-DCP was positively detected in 3 of 30 samples and cis-1,2-DCE was detected in only 1 of 30 samples. When comparing upgradient (Table 6-1) to downgradient (Table 6-7) TCE detections, it is evident that TCE is detected less often and at lower concentrations along the downgradient Base perimeter. Also, the maximum concentration reported downgradient is 39 μg/L, compared to the maximum upgradient concentration of 520 μg/L. Some combination of dilution, degradation, and sorption accounts for the attenuation observed between the northern and southern Base boundaries, which are approximately 1,900 feet apart.

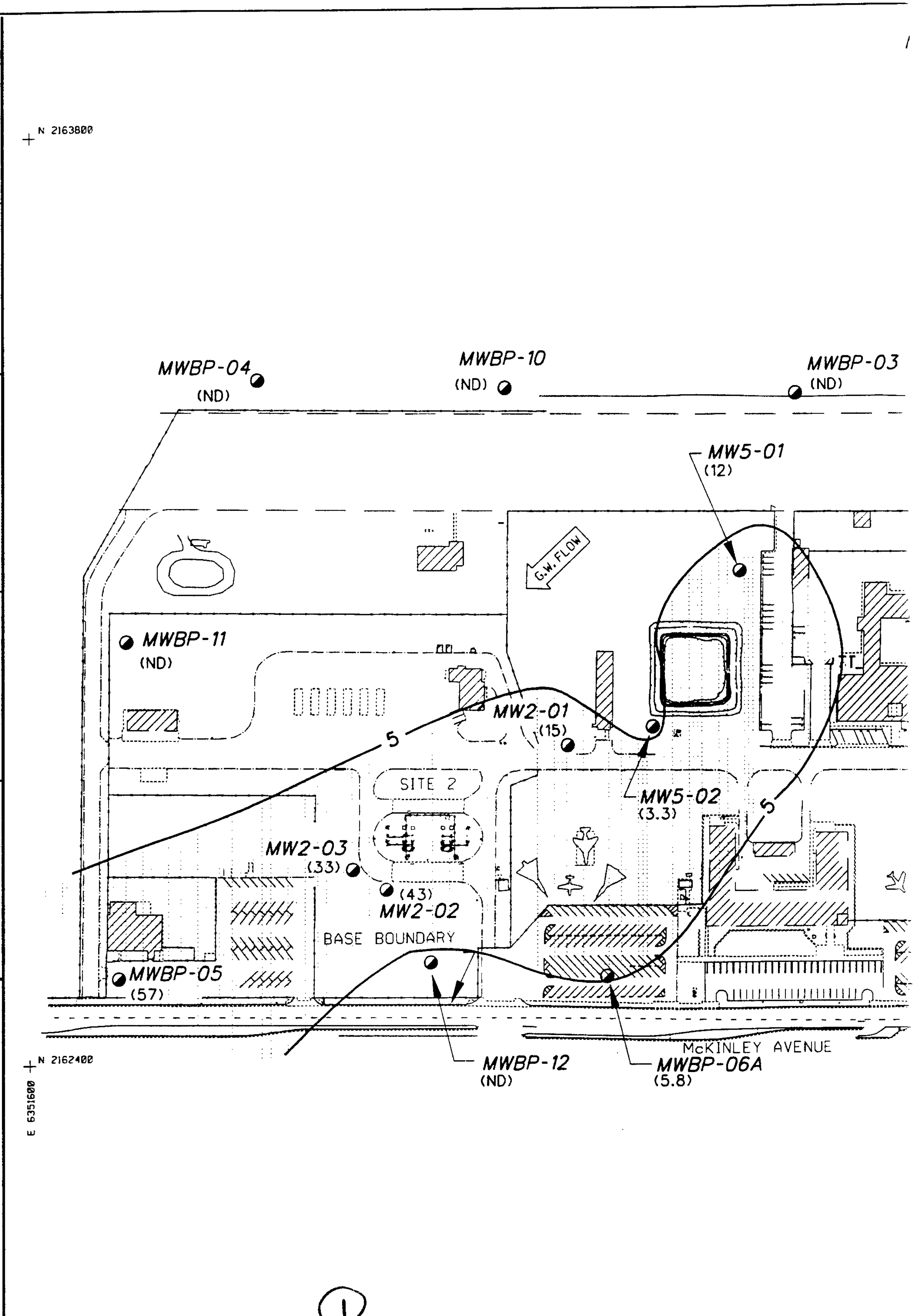
Conversely, PCE in groundwater originates at or near Site 5-BCP and migrates with groundwater towards the southwest. Figure 6-4 shows the approximate boundaries of the PCE plume with the latest available sample data. The boundaries are constrained to the west between MWBP-11 and MWBP-05 and to the southeast between MWBP-06A and MWBP-07. As seen in Figure 6-4 and Table 6-6, PCE concentrations increase with distance from Site 5-BCP. This implies that the majority of the mass of PCE in groundwater has migrated outside of Base property. The downgradient extent of PCE has not been defined.

The trend of decreasing PCE concentrations discussed in Section 6.2.2.2 at Site 5-BCP also applies to downgradient Base perimeter wells. Concentrations at MWBP-05 have decreased to roughly half the level first measured in November 1990 (Table 6-6). Less concentrated groundwater is moving through this point, either caused by the contaminant mass migrating beyond the Base boundary and/or by attenuation mechanisms.

PCE concentrations at MWBP-06A have remained relatively stable over its sampling history. Because PCE is not normally detected in MWBP-12, which lies between MWBP-06A and MWBP-05 (Figure 4-4), the detections of PCE in MWBP-06A indicate that a locally southern flow component exists between the source area and this well. This should be taken into account when and if additional investigations are conducted off Base property.

SVOCs were only periodically detected over the three rounds for which they were analyzed. bis(2-Ethylhexyl)phthalate was reported twice and chrysene was detected once in 14 samples (Table 6-7). Each reported concentration was an estimated quantity below the detection limit.

STARTING DATE: 10/13/95	DATE LAST REV.:	DRAFT. CHCK. BY: C.TUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.061
DRAWN BY: D.BILLINGSLEY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724



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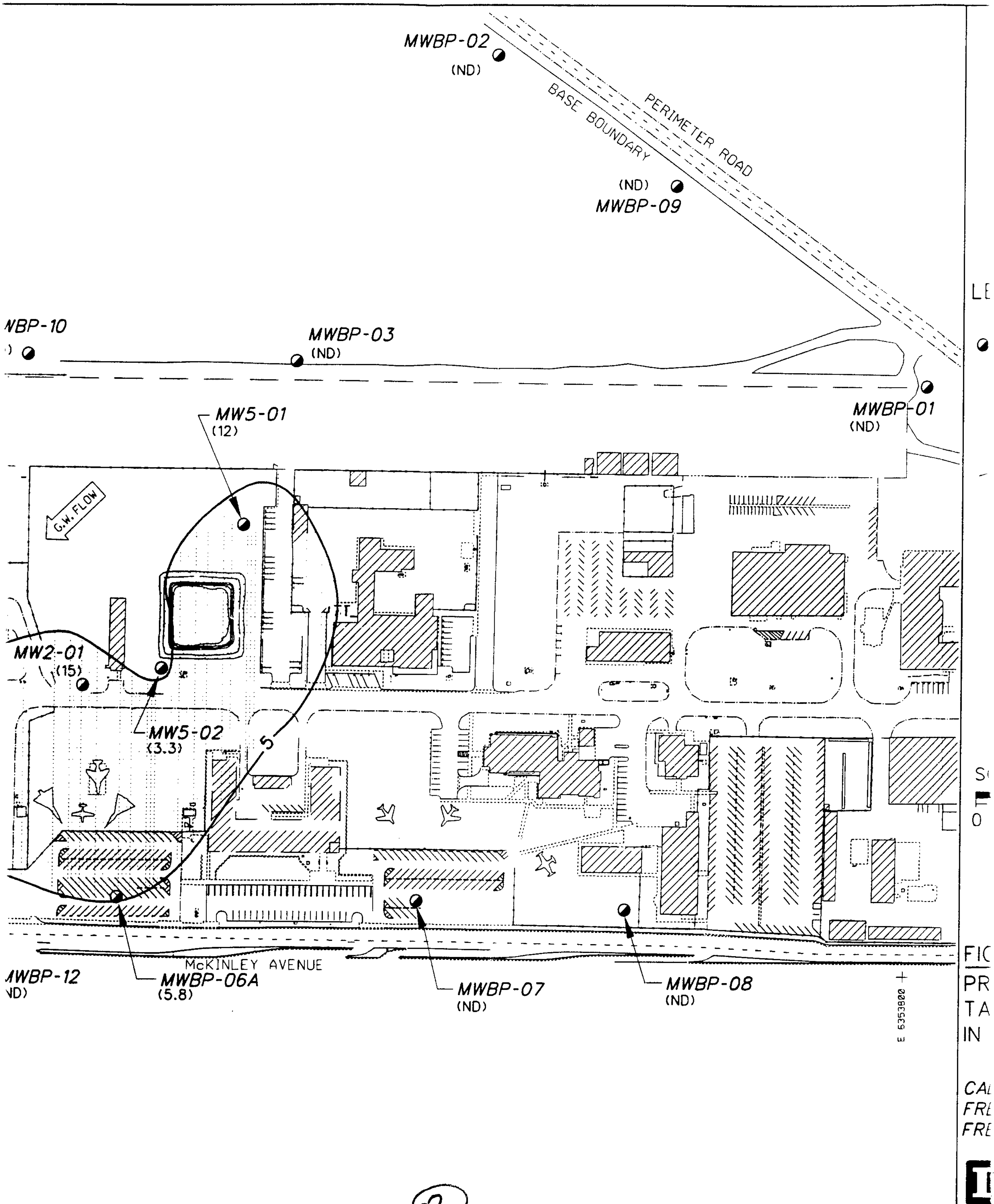
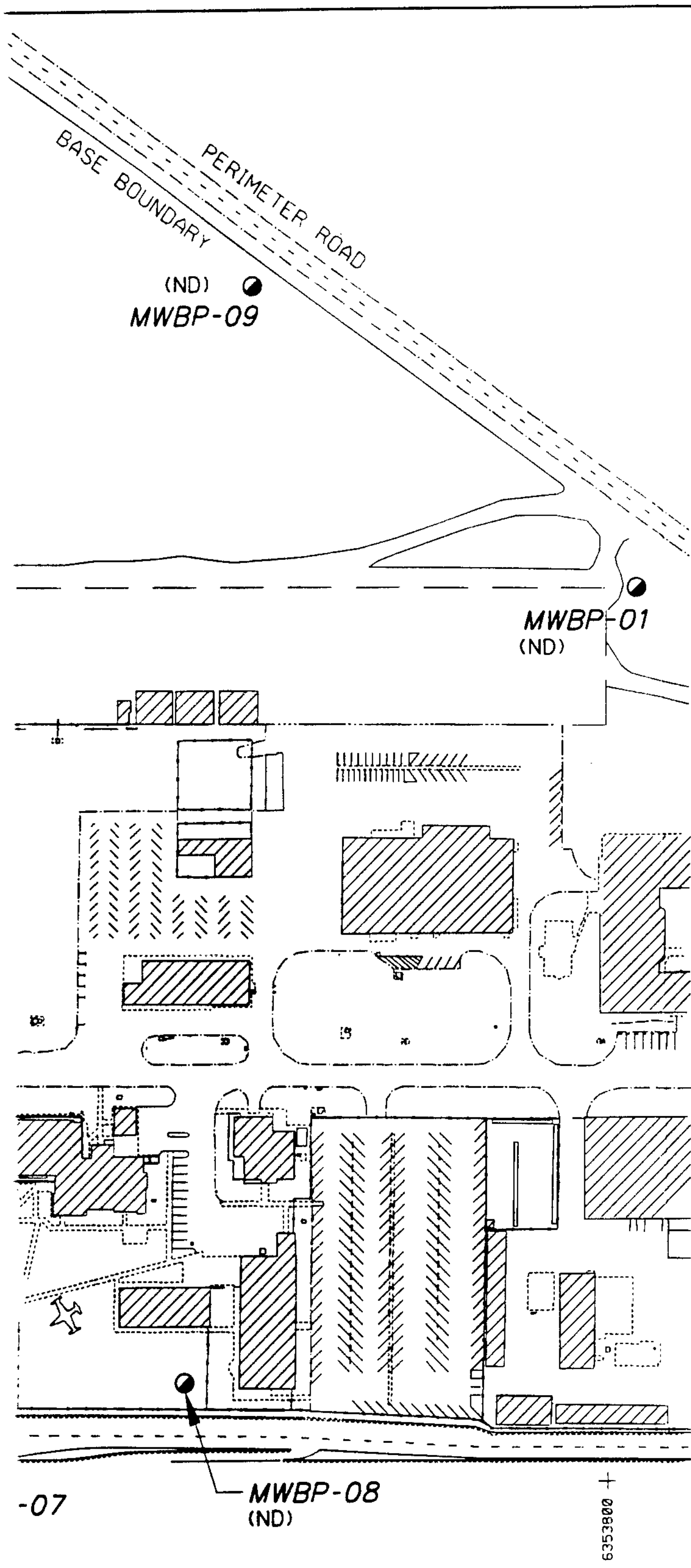

MWBP-02
(ND)
PERIMETER ROAD
BASE BOUNDARY
(ND)
MWBP-09
LE
WBP-10
MWBP-03
(ND)
MWBP-01
(ND)
MW5-01
(12)
G.W. FLOW
MW2-01
(15)
MW5-02
(3.3)
5
McKINLEY AVENUE
WBP-12
ND)
MWBP-06A
(5.8)
MWBP-07
(ND)
MWBP-08
(ND)
E 6353800
S
0
FI
PR
TA
IN
CA
FR
FR

2



LEGEND:

MWBP-12 (1.6)	MONITORING WELL WITH PCE CONCENTRATION IN uG/L
(ND)	NOT DETECTED
5	CALIFORNIA DRINKING WATER STANDARD FOR PCE
G.W. FLOW	GROUNDWATER FLOW DIRECTION
	PCE PLUME AREA

SCALE:

0 200 400 FEET

FIGURE 6-4

PRESENCE OF PCE AT THE WATER TABLE FOR SAMPLES COLLECTED IN APRIL 1993

CALIFORNIA AIR NATIONAL GUARD
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FRESNO, CALIFORNIA

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6.4 Deep Aquifer Investigation Results

6.4.1 Screening Activity Results

Deep aquifer program screening activities consisted of soil and groundwater screening sample collection and analysis, and downhole geophysical logging of two exploratory borings. Screening analyses were utilized primarily for guiding the progression of the exploratory program to identify the zones of interest for subsequent deep monitoring well installation. Because screening data evaluation was required for designing the deep monitoring well network, screening sample results are discussed in Section 4.5.2. Screening information was also used to verify visual geologic logs from the exploratory borings (Section 4.5.1.5) and for determining the appropriate disposal option for the waste soil from all of the deep aquifer investigation boreholes (Section 4.7.1).

6.4.1.1 Deep Aquifer Groundwater Screening Sample Results

Groundwater screening samples were used to determine the depth of groundwater contamination and the relative concentrations of contaminants. The results were used to determine the placement depths of the deep monitoring wells to be installed. A complete listing of the screening results are provided in Table 4-6. Screening sample results that influenced the deep monitoring well network design are discussed in detail in Section 4.5.2, and are also interpreted with the hydrogeologic setting in Section 5.3.2. Previous discussions focused primarily on the presence and absence of PCE in groundwater. The following discussion compares the presence of TCE in groundwater below the water table in screening versus monitoring well samples.

In almost each case, when a monitoring well was installed at the same general depth where a groundwater screening (Hydropunch) sample was collected, the screening sample detected higher concentrations of TCE. This is likely due to groundwater in a monitoring well being a mixture from different layers, whereas the screening sample is much more discrete in where its groundwater is drawn from. Sample pairs that do not match this observation are at the upgradient location in wells MWBP-09B and -09C. Groundwater screening samples did not detect any TCE from the same intervals at which monitoring wells were later installed (Figure 5-3), yet well MWBP-09B contains TCE at a concentration of 500 μg/L and MWBP-09C reported TCE at 25 μg/L.

This discrepancy is likely a function of the geologic medium sampled. From Figure 5-3, the screening sample collected at an elevation of 210 feet msl is located below the bottom of the

screened interval in well MWBP-09B. The screening sample was collected from a silt unit, whereas the monitoring well screens two thin sand layers. It is likely that the sand layers contain TCE and the underlying silt layer where the screening sample was collected does not contain TCE.

Similarly, the screening sample colocated with well MWBP-09C was collected from a silty sand unit, which underlies a relatively thick clean sand unit. TCE may be present in the sand unit, but not in the silty sand unit where the screening sample was collected.

Groundwater screening sample results within what is interpreted to be the A/B aquitard (Figure 5-3) consistently showed no TCE (or PCE), except in the sample collected at downgradient location EXB-05, where 180 µg/L TCE was detected at an elevation of 98 feet msl. This result appears anomalous considering that shallower screening samples showed much lower TCE concentrations. However, it also may indicate flow of groundwater through this aquitard. The simple fact that screening samples were able to be collected from the aquitard indicates some amount of groundwater flow through it. Screening samples collected from upgradient boring EXB-03 indicated TCE in the 320 to 120 µg/L range, and this groundwater may be migrating vertically into the A/B aquitard. Because of the compaction of the silt material within the A/B aquitard, groundwater and contaminants may become bound in the matrix and accumulate instead of continuing to migrate further downgradient. When reviewing Figure 5-3, it must also be remembered that boring EXB-04 is offset some 400 feet to the southeast of the main cross-sectional line.

6.4.1.2 Geophysical Logging Comparison

Two of the five exploratory borings (EXB-01 and EXB-02) were logged both visually and with downhole geophysics. The correlation and comparison between the two different logs are described in detail in Section 4.5.1.5. A more detailed evaluation of the comparison is also included in a technical paper published based on the findings of the deep aquifer investigation field effort. This paper is presented in its entirety in Appendix D.

6.4.1.3 Deep Aquifer Soil Screening Sample Results

Soil screening samples were used to determine if any chlorinated organics were present in the soil matrix at depth in order to determine the appropriate method of soil disposal. A minimum of one soil screening sample was collected from every 50-foot interval in each exploratory boring. Screening results from the exploratory borings were used as surrogate

data for the disposal of the soil cuttings from the monitoring well boreholes. Results of the screening analyses are available in Appendix A. Use of the data is discussed in Section 4.7.1.

The absence of contaminants in the majority of soil screening samples allowed for waste soil from the exploratory borings and monitoring well boreholes to be disposed on Base.

6.4.2 Deep Monitoring Well Groundwater Sample Results

Groundwater samples were collected from the eight deep monitoring wells in December 1993 and February 1995. Deep monitoring well locations are shown in Figure 4-6. Well depths and screened intervals are listed in Appendix B and shown in Figure 5-3. Sampling results for detected compounds are summarized in Table 6-8 and are shown in cross-sectional form in Figure 6-5.

Three compounds were positively detected among the samples: TCE, PCE, and 1,2-DCP. Only PCE is considered to be directly related to past ANG activities. Three sample results were eliminated based on blank correction of the data (Appendix I).

1,2-DCP was detected once in deep well MWBP-05C at a concentration of 3.9 μg/L.

TCE was detected in each well for both sampling events. As expected, the highest concentrations were reported from upgradient well MWBP-09B, with concentrations of 500 and 350 μg/L (Table 6-8). Of interest is the pattern of TCE concentrations with position and depth (Figure 6-5). Within the B zone (lower A1 aquifer), TCE concentrations are highest at the upgradient position and decrease in the downgradient locations: 200 μg/L at MW5-01B, and approximately 100 μg/L at MWBP-05B. Lateral gradient well MWBP-06B reported lower concentrations (approximately 5 μg/L).

Within the C zone (A2 aquifer), the trend of TCE concentrations does not follow the "B" zone. Higher concentrations were measured at downgradient wells MW5-01C and MWBP-06C than at upgradient well MWBP-09C (Table 6-8). TCE, therefore, appears to migrate vertically downward as it moves with groundwater across Base property. TCE concentrations decrease slightly at the MWBP-05C position, indicating that perhaps additional vertical movement occurs between MW5-01C and MWBP-05C. These observations are consistent with discussions of vertical hydraulic gradients in Section 5.3.3. TCE is not, however, related to past Base activities.

Table 6-8

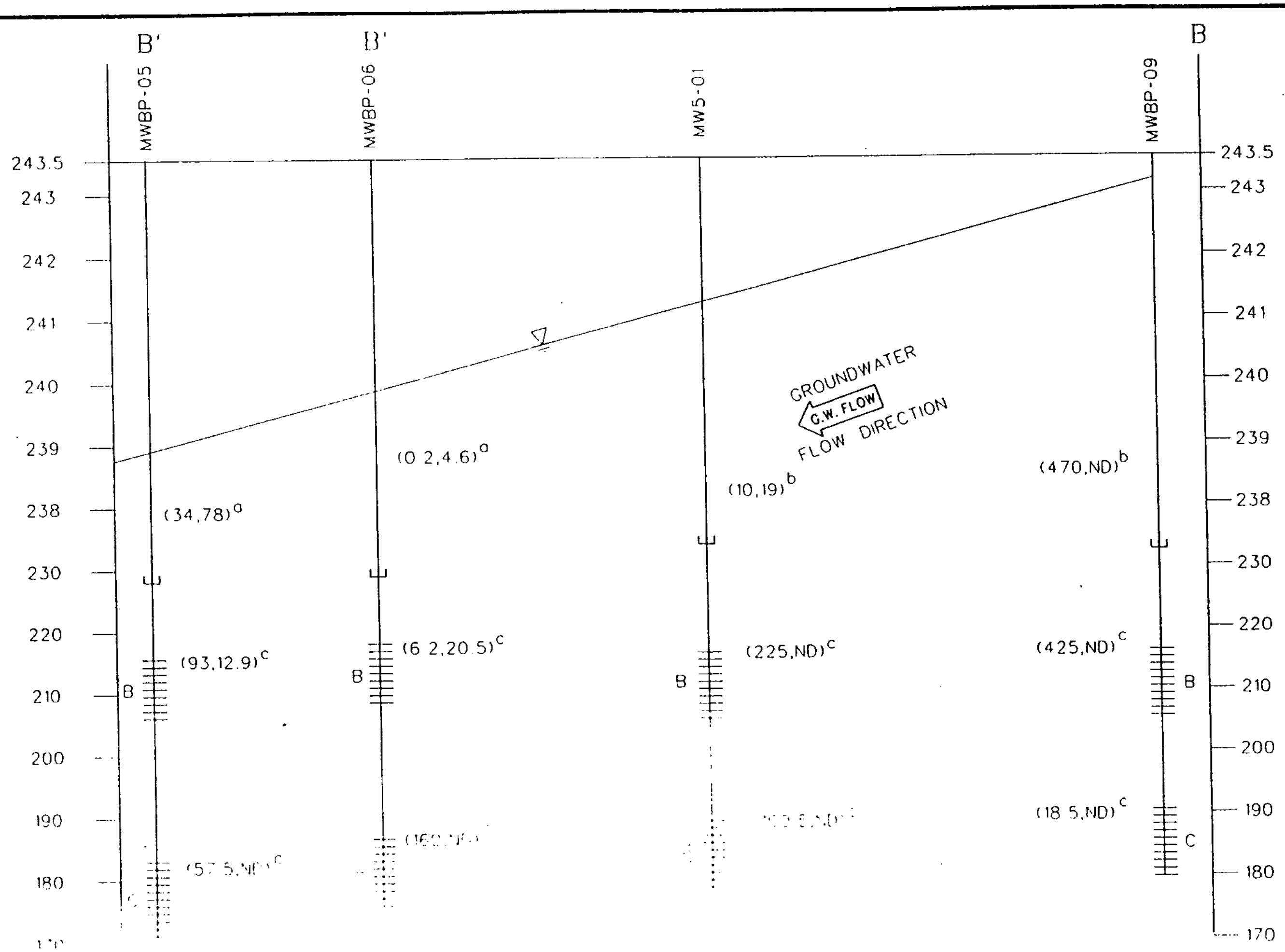
Summary of Deep Monitoring Well Groundwater Sample Results California Air National Guard - Fresno, California

Area ID	Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
Base Perimeter - Upgradient	MWBP-09B-12/93	TCE[a]	µg/L	500			12/08/93
	MWBP-09B-12/93Z	TCE[a]	µg/L	520			12/08/93
	MWBP-09B-2/95	TCE[a]	µg/L	350			02/14/95
	MWBP-09C-12/93	TCE[a]	µg/L	25			12/08/93
	MWBP-09C-2/95	TCE[a]	µg/L	12			02/14/95
Site 5	MW5-01B-1293	TCE[a]	µg/L	250			12/08/93
	MW5-01B-2/95	TCE[a]	µg/L	200			02/14/95
	MW5-01C-12/93	TCE[a]	µg/L	120			12/09/93
	MW5-01C-2/95	TCE[a]	µg/L	81			02/15/95
Base Perimeter - Downgradient	MWBP-06B-12/93	PCE	µg/L	23			12/09/93
	MWBP-06B-2/95	PCE	µg/L	18			02/15/95
	MWBP-06B-12/93	TCE[a]	µg/L	7.5			12/09/93
	MWBP-06B-2/95	TCE[a]	µg/L	4.8			02/15/95
	MWBP-06C-12/93	TCE[a]	µg/L	260			12/09/93
	MWBP-06C-2/95	TCE[a]	µg/L	60			02/15/95
	MWBP-05B-12/93	PCE	µg/L	16			12/09/93
	MWBP-05B-2/95	PCE	µg/L	9.8			02/15/95
	MWBP-05B-12/93	TCE[a]	µg/L	130			12/09/93
	MWBP-05B-2/95	TCE[a]	µg/L	56			02/15/95
	MWBP-05C-12/93	1,2-DCPa	µg/L	3.9			12/09/93
	MWBP-05C-12/93	TCE[a]	µg/L	62			12/09/93
	MWBP-05C-2/95	TCE[a]	µg/L	53			02/16/95

NOTES:

[a] Not an ANG-related chemical (see Section 6.1.2).

Samples with a "Z" suffix are field duplicate samples.



LEGEND:

SCREEN INTERVAL FOR B/C WELLS

BOTTOM OF SCREEN FOR WATER TABLE WELL

WATER TABLE ELEVATION

(93,12.9) AVERAGE TCE, PCE CONCENTRATION IN uG/L

ND NOT DETECTED

NOTES:

a AVERAGE CONCENTRATION OF 6 SAMPLES COLLECTED FROM 11/90 TO 4/93.

b AVERAGE CONCENTRATION OF 3 SAMPLES COLLECTED FROM 10/92 TO 4/93.

c AVERAGE CONCENTRATION OF SAMPLES COLLECTED 12/93 AND 2/95.

THE HYDROGEOLOGIC SETTING IS PRESENTED ON FIGURE 5-3.

HORIZONTAL SCALE:
0 400 800 FEET

VERTICAL SCALE: AS NOTED

FIGURE 6-5
PRESENCE OF TCE AND PCE IN DEEP MONITORING WELLS

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FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE 10/15/95	DATE LAST REV	DRAFT CHCK BY: C TUMLIN	INITIATOR: S LOGAN	DWG NO 409724es.052
DRAWN BY D BILLINGSLEY	DRAWN BY	ENGR CHCK BY: S LOGAN	PROJ MGR: D.BURTON	PROJ. NO 409724

PCE was only detected in two wells: MWBP-05B and MWBP-06B. It was not reported in any C series wells (Figure 6-5), although the downward migrating trend of TCE suggests that the potential exists for this to occur. Groundwater samples from MW5-01B and MW5-01C did not detect PCE even though they are located nearest to the presumed source area. Given the slight mounding of groundwater directly under Site 5-BCP from infiltrating water, it would be expected that local vertical gradients would be produced that would allow PCE to migrate to depths similar to that of MW5-01B. It is probable that this happened at one time. However, no contamination is currently entering the groundwater system and contamination that is present in the water is residual in nature. No PCE is migrating to significant depths at Site 5-BCP. The contamination that is theorized to have existed at one time has migrated away from the area, has degraded, or has been diluted to concentrations that cannot be detected.

6.4.3 Deep Aquifer Investigation Discussion

The initial deep aquifer investigation allowed for a detailed description of subsurface hydrogeology and contaminant distribution across Base property. Geologic and hydrogeologic discussions and interpretations have been previously presented in Section 5.3 and are summarized in this section.

The aquifer system to a depth of 250 feet bgs is typical of aquifers in alluvial environments. Sand layers are not uniform in either composition or thickness across the Base, indicating a heterogeneous hydrogeologic framework. Aquitards, composed of fine-grained and compacted coarser-grained lithologies, also do not exhibit uniform properties across the area. The result is an interconnected network of permeable and less permeable materials that are connected to some degree across the study area. Even an identified thick, nearly indurated, apparently uniform silt bed across the Base does not appear to act as a classic aquitard.

Groundwater contamination is present at the water table across Base property. By the time groundwater moves to the extreme southwestern end of the Base, TCE contamination has migrated to depths of at least 250 feet bgs. Groundwater contamination appears to be limited to the upper zones of the aquifer (depth of 150 feet bgs) at the upgradient Base locations. Sufficient barriers to vertical groundwater flow do not exist across much of Base property, thus allowing TCE and other constituents to move to greater depths.

PCE was only detected in wells at downgradient locations. Its presence appears to be restricted to only the upper 45 feet of saturated sediments. PCE was not detected in any C

series (A2 aquifer) wells. However, given the ability of TCE to migrate to greater depths, its is conceivable that PCE could follow this pattern. Yet, TCE concentrations (500 to 130 μg/L) are much higher than PCE concentrations (10 to 20 μg/L); higher TCE concentrations may create chemical gradients that assist in its downward migration. Chemical gradients for PCE are much smaller. This lower chemical gradient, combined with low vertical hydraulic gradients, produces a lower vertical movement potential for PCE than TCE.

At the water table, the downgradient extent of PCE groundwater contamination has not been defined. Only low concentrations of PCE were measured in the intermediate depth wells and this may suggest that the greater mass of PCE in groundwater has migrated off Base property. However, low PCE concentrations equate to low chemical gradients, which as previously discussed, may produce a lower vertical migration potential for PCE as it flows further down-gradient.

Aquifer tests conducted in the B zone (lower A1 aquifer) showed excellent communication between this and the A aquifer zone (upper A1 aquifer). Communication between the B and C zones (A1 and A2 aquifers, respectively) was unable to be determined. It is possible that a local aquitard exists between the B and C zones within the southwestern portion of the Base. This may also explain why PCE contamination has not been measured in the C wells. The aquifer tests showed that both the A and B zones can sustain reasonable pumping rates. If mass removal is a future remedial goal, then extraction wells could be installed with small screened intervals in the zones of highest contamination to attack the areas of greatest concern. If hydraulic control is a future remedial goal, then wells should be installed to intercept both the A and B zones. Additional testing may also be able to define the amount of local communication between the B and C zones so that hydraulic control is optimized.

From the two rounds of sampling from the deep monitoring wells, it can be asserted that the C zone has not been impacted by PCE. Any site-specific remedial measures that may be considered for this local plume should, therefore, be constrained to just the A1 aquifer. Information concerning PCE migration depths outside of Base property is not presently available. PCE is dissolved within the lower A1 aquifer at very low concentrations (maximum of 23 μg/L) and would be expected to migrate with groundwater, attenuation mechanisms notwithstanding. Given the vertical migration trend of TCE, it is plausible that PCE also has the potential to migrate to deeper aquifer zones with increasing distance from the source area.

7.0 Discussion of Potential ARARs

7.1 Introduction

This chapter describes ARARs potentially applicable to the remediation of the Fresno ANG sites under the Comprehensive Environmental Response Compensation, and Liability Act (CERCLA). Because a final remedial plan has not been established, the list of ARARs discussed in this chapter should be viewed as preliminary. However, because the final remedy will likely be limited to several technologies and to one media (groundwater), the list established here should provide a working framework for establishing the final ARARs list during the development of any future remedial alternatives and strategies. An emphasis has been placed on identifying key ARARs, and those ARARs that could have a significant impact on the selected remedial action. Also identified are the steps that will need to be taken to ascertain a final list of ARARs once the final remedy has been selected.

The identification of ARARs is a requirement of CERCLA. CERCLA created a federal program for the cleanup of uncontrolled releases of hazardous substances into the environment. The Superfund Amendments and Reauthorization Act (SARA), enacted in 1986, reauthorized the program for an additional 5 years; the Omnibus Reconciliation Act of 1990 again extended the CERCLA program. SARA added guidance on developing cleanup standards, a preference for permanent solutions and support for the development of innovative technologies, and codified many EPA practices that evolved during site evaluation and remediation occurring in the first years of the CERCLA program.

CERCLA provides virtually no guidance on the specific cleanup standards that should be applied to a remedial action, or to the criteria for choosing among remedial alternatives. Instead, selection criteria and cleanup standards are addressed in the implementing regulations for CERCLA and SARA, Title 40 Code of Federal Regulations (CFR) Part 300, which are referred to as the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Nine selection criteria for choosing among remedial actions are presented in Subpart E - Hazardous Substance Response, 40 CFR 300.430(e)(9). One of these nine criteria requires that the action complies with ARARs. The NCP further defines the criteria for remediating a facility by requiring that on-site remedial actions attain or exceed the ARARs in federal and state environmental and public health laws.

7.2 ARARs Defined

Section 121(d) of CERCLA requires that at the completion of remedial actions, the site should achieve a level of control that complies with federal and state environmental laws that are applicable or relevant and appropriate for the hazardous substances, pollutants, or contaminants that remain on site. "Applicable" requirements are those "cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site." Only those state standards identified in a timely manner and that are more stringent than federal requirements may be applicable (40 CFR 300.5). "Applicable" implies that the remedial action or the circumstances at the site satisfy all of the jurisdictional prerequisites of a requirement.

If a requirement is not "applicable" to a specific release, it may instead be "relevant and appropriate." Relevant and appropriate requirements are those "cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable to a hazardous substances, pollutant, contamination, or remedial action, location, or other circumstance at that CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site" (40 CFR 300.5). However in some circumstances, a requirement may be "relevant" but not "appropriate" for the site-specific situation. A requirement must be both "relevant and appropriate" to be afforded this status.

Section 121 of CERCLA requires selection of a remedial action that is protective of human health and the environment. Such protectiveness, as determined by a site risk assessment, may not always be attained by the ARARs available in federal and state laws. In certain cases, standards may not exist in the promulgated regulation that address the proposed action or the constituent of concern. In these cases, nonpromulgated advisories, criteria, or guidance that were developed by the EPA, other federal agencies, or states are to be considered (TBC) in establishing remedial action objectives that are protective of human health and the environment. In addition, TBCs may provide information that is utilized to develop CERCLA remedies.

In addressing a requirement that may affect a remedial action being considered for a site, a determination is made regarding its relationship to: (1) the location of the action, (2) the contaminants involved, and (3) the specific components of the action, such as factors unique

to a certain technology. Three types of ARARs advisory result from this process: location-specific ARARs, chemical-specific ARARs, and action-specific ARARs.

The formal definition of the term "site" in the context of this CERCLA RI includes not only the areas contaminated, but also the area contaminated by the migration of a hazardous substance, pollutant, or contaminant from any of the properties under the custody or accountability of the Fresno ANG. The term "on property" is included in the definition of "on site," but includes only that part of the site under direct control or ownership of the Fresno ANG. The term "off site" refers to all other areas that are not included in the definition of "on site." On-site actions are required to comply with ARARs, but must comply only with the substantive parts of an ARAR. The application of specific environmental regulations to activities being considered for off-site facilities, such as land disposal of waste at a permitted commercial disposal site, would be addressed by the facility owners/operators in the environmental compliance documents and requirements that govern those facilities.

7.3 ARAR Identification Methodology

The process of identifying ARARs and TBC material for the Fresno ANG is described in this section.

The first step in identifying the ARARs for the site involves identifying the potential contaminant and action- and location-specific requirements. The next step involves analyzing those requirements to determine if they are applicable. For a requirement to be applicable, the site circumstances must meet all jurisdictional prerequisites of the requirement. Such jurisdictional prerequisites may include:

- Who, as specified by the statue or regulation, is subject to its authority
- What types of substances or activities are listed as falling under the authority of the statute or regulation
- The time period for which the statute or regulation is in effect
- The types of activities the statute or regulation requires, limits, or prohibits.

If the requirements fail to meet a jurisdictional prerequisite, the requirement is not applicable. The analysis then must address whether the requirement is relevant and appropriate. The evaluation factors used for determining whether a requirement is relevant or appropriate include:

- Whether the specific objectives of the statute and regulations under which the requirement was created are similar to the specific objectives of the CERCLA action

- Whether the media regulated or affected by the requirement are similar to the media contaminated or affected at the CERCLA site

- Whether the substances regulated by the requirement are similar to the substances found at the CERCLA site

- Whether the entities or interests affected or protected are similar to the entities or interests affected by the CERCLA site

- Whether the actions or activities regulated by the requirement are similar to the remedial action contemplated at the CERCLA site

- Whether the type of place regulated is similar to the type of place affected by the CERCLA site or CERCLA action

- Whether any consideration of use or potential use of affected resources in the requirement is similar to the use or potential use of the affected resource

- Whether the purpose of the requirement in the program of its origin is served by its application at the CERCLA site.

- Whether any variances, waivers, or exemptions from the requirements are available for the circumstances of the CERCLA site or CERCLA action.

If a regulatory scheme appears to be relevant and appropriate, each provision in that scheme should be reviewed to determine its relevance and appropriateness for the site. If an evaluation of a provision against these factors indicates that the site circumstances are "sufficiently similar" to the problems addressed by the provision, then the provision should be selected as relevant and appropriate. Otherwise, it should be dropped from consideration. When the analysis results in a determination that a requirement is both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable.

If an ARAR does not exist, or it is not sufficiently protective of human health and the environment, then criteria, guidance, proposed rules, advisories, or other TBCs developed or approved by federal or state agencies should be analyzed for their pertinence in establishing a

protective remedy. These TBC materials, which are not legally binding, become enforceable if they are incorporated into the cleanup order, or record of decision (ROD).

An initial listing of potential ARARs is presented in Table 7-1a through -1d. This listing is divided to separate action-, location-, chemical-specific ARARs, and other considerations. A comprehensive listing of ARARs will be developed once a remedy is selected, and must include input from the State of California Environmental Protection Agency and EPA.

If a requirement is determined to be an ARAR, it must be complied with unless a condition addressed by CERCLA criteria for a waiver is encountered. Under Section 121(d)(4) of CERCLA, EPA may waive compliance with an ARAR if one of the following conditions can be demonstrated:

- The remedial action selected is only an interim measure and will become part of a total remedial action that will attain the ARAR level or standard of control when completed.
- Compliance with the requirement will result in greater risk to human health and the environment than other alternatives.
- Compliance with the requirement is technically impracticable from an engineering perspective.
- The remedial action selected will attain a standard of performance that is equivalent to that required by the ARAR through the use of another method or approach.
- The state has not consistently applied (or demonstrated an intention to consistently apply) the promulgated requirement in similar circumstances at other remedial actions.
- Attainment of the ARAR would not provide a balance between the need for protection of public health or welfare and the environment at this site, and the availability of CERCLA monies to respond to other sites that may present at threat to public health or the environment.

7.4 ARAR Development

RI activities have provided considerable information regarding site contamination and waste characterization, and have allowed for the preliminary identification of ARARs. Discussions with EPA Region IX and the State of California concerning various regulations and their inclusion will likely continue until a final cleanup order is issued. The following steps to arriving at final ARARs are proposed:

Table 7-1a

Potential ARARs
Chemical-Specific
California Air National Guard - Fresno, California

Media	Program	Potential Requirements	ARAR/TBC	Implementation
Water	Safe Drinking Water Act 40 CFR 141.11, 141.51, 141.61 and 141.62	Groundwater must be treated to attain the more stringent MCL or nonzero MCLG (µg/L): (chemical: MCL / MCLG / State MCL) Lead: NA / NA / 50 cis-1,2-Dichloroethene: 70 / 6 / 6 Tetrachloroethene: 5 / NA / 5 Trichloroethene: NA / 5 / 5 Carbon tetrachloride: 5 / NA / 0.5 1,2-Dichloropropane: 5 / NA / 5 bis(2-Ethylhexyl)phthalate: NA / NA / 4	Relevant and applicable	These requirements are not applicable since no public water system (as defined in 40 CFR 141) is involved. However, they are considered relevant and appropriate to protect drinking water sources from the same contaminants found in the site. These contaminants might migrate or leach into the underling aquifer as a consequence of various alternatives. CERCLA Section 121(d)(2)(A) requires on-site remedies to attain MCLGs where relevant and appropriate under the circumstances of the release. If the MCLG is equal to zero, EPA believes it is not appropriate for setting cleanup levels, and the corresponding MCL will be the potentially relevant and appropriate requirement
Air	California Air Pollution Control (CARB) Regulations, Title 17	No specific ARARs have been identified at this time. The CARB should be contacted to identify specific requirements when alternatives are selected for further evaluation.	Applicable	The remedial activities should not significantly impact air quality. The treatment of the groundwater will likely generate organic emissions that are regulated by the State of California. Specific control devices such as burners, flares, etc., may entail additional requirements and controls.
Water	Chemicals in Drinking Water (Solid Waste Disposal Facility) 40 CFR 257.3-4	A solid waste disposal facility shall not contaminate an underground drinking water source beyond the solid waste boundary (outermost perimeter of the waste). The concentration of chemicals shall not exceed background, or listed MCLs, whichever is higher.	Relevant and appropriate	On-site disposal of solid waste might cause migration into the underlying aquifer and potentially contaminate drinking water systems as a consequences of remedial actions.

Table 7-1b

Potential ARARs
Location-Specific
California Air National Guard - Fresno, California

Regulation	Requirement	ARAR/TBC	Implementation
Water Supply	Fresno is a sole source aquifer. Specific requirements may apply, but have not been determined at this time.	Applicable	Additional clarification as to any specific requirements should be provided by the California Water Resources Control Board.

Table 7-1c

Potential ARARs
Action-Specific
California Air National Guard - Fresno, California

(Page 1 of 3)

Regulation	Requirement	ARAR/TBC	Implementation
RCRA Subtitle C (40 CFR 262.11) Hazardous Waste Determination [California Hazardous Waste Management Regulations, Title 22]	Any generator of waste must determine whether or not the waste is hazardous. The procedures to be followed include: • Identify whether a particular material of concern is a "solid waste." • Identify whether a particular solid waste might be classified as a hazardous waste. • Determine if a material otherwise classified as a "hazardous waste" might be excluded from RCRA regulation.	Applicable	These procedures are established to determine whether wastes are subject to the requirements of RCRA. The residues in the soil, such as will be encountered in drilling cuttings, wash water, etc. will not be considered listed waste, but must be analyzed to determine whether it is a hazardous waste. Native materials such as soil and water that is not inherently waste-like, if free of contamination will be allowed to be placed back on the land. Solid and hazardous wastes as defined under RCRA must be treated, stored, and disposed in accordance with RCRA requirements.
RCRA Subtitle C (40 CFR 264.171 - 178 Subpart I) [California Hazardous Waste Management Regulations, Title 22]	Containers of RCRA hazardous waste must be: • Maintained in good condition • Compatible with hazardous waste to be stored • Closed during storage (except to add or remove waste) • Storage areas inspected weekly for leaking and deteriorated containers and containment system.	Applicable	RCRA waste stored prior to shipment for treatment, storage, or disposal can be stored at a container storage area meeting the design criteria specified in this section.

Table 7-1c

Potential ARARs
Action-Specific
California Air National Guard - Fresno, California

(Page 2 of 3)

Regulation	Requirement	ARAR/TBC	Implementation
RCRA Subtitle C (40 CFR 264.171 - 178 Subpart I) [California Hazardous Waste Management Regulations, Title 22] (Continued)	Place containers on a sloped, crack-free base, and protect from contact with accumulated liquid. Provide a containment system with a capacity of 10 percent of the volume of the largest container or free liquids. Remove spilled or leaked waste in a timely manner to prevent overflow of containment system. Keep incompatible materials separate. Separate incompatible materials stored near each other by a dike or other barrier. At closure, remove all hazardous waste and residue from the containment system, and decontaminate or remove all containers, liners, asbestos, and soils.		
RCRA Subtitle C (40 CFR 261.7) [California Hazardous Waste Management Regulations, Title 22]	Containers that have held hazardous wastes are "empty" and exempt from further RCRA regulations if one or more of the following are met: • No more than 2.5 cm (1 inch) of residue remains on the bottom of the inner liner. • Less than 3 percent by weight of total capacity remains (less than or equal to 110 gallon container). • Less than 0.3 percent by weight of total capacity remains (greater than 110 gallon container). Containers that have held acutely hazardous (P listed) wastes are "empty" and exempt from further RCRA regulation if: • Containers or their inner liners have been triple-rinsed with an adequate solvent or the inner liner has been removed from the container.	Applicable	Containers that held RCRA hazardous waste that are emptied/decontaminated in accordance with this requirement will be considered non-RCRA regulated.

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Table 7-1c

Potential ARARs
Action-Specific
California Air National Guard - Fresno, California

(Page 3 of 3)

Regulation	Requirement	ARAR/TBC	Implementation
RCRA Subtitle C (40 CFR 262.20-262.23) Generators who transport hazardous waste for off-site treatment, storage, or disposal [California Hazardous Waste Management Regulations, Title 22]	Any generator who transports hazardous waste for off-site treatment, storage, or disposal must originate and follow up the manifest for off-site shipments.	Applicable	Any residues determined to be RCRA hazardous waste removed from this site for off-site treatment, storage, or disposal will be subject to the manifest requirement.
RCRA Subtitle C (40 CFR 268, Subpart D) land disposal restrictions [California Hazardous Waste Management Regulations, Title 22]	Generally prohibits the placement of restricted RCRA hazardous waste in land-based units such as landfills, surface impoundments, waste pikes and land facilities, unless specific technology or treatment based standards are first met.	Applicable	The contaminated materials at the ANG will not be listed, but must comply with the land disposal restrictions requirements for characteristic hazardous waste, if found to be hazardous by characteristic.
California Water Well Construction/Closure Requirements	Well construction and closure must comply with California guidance.	TBC	Construction and closure must follow the requirements established in *Monitoring Well Design and Construction for Hydrogeologic Characterization - Guidance Manual for Ground Water Investigations*, State of California, Environmental Protection Agency, GB1025.M78, 1994. Sampling of monitoring wells shall follow the requirements specified in *Represenative Sampling of Ground Water for Hazardous Substances, Guidance Manual for Ground Water Investigations*, State of California Environmental Protection Agency, GB1025.R34, 1994.

Table 7-1d

Potential ARARs - Other Requirements
California Air National Guard - Fresno, California

Regulation	Requirement	Implementation
OSHA Worker Protection Requirements 29 CFR 1904, 1910	These requirements establish requirements to protect workers who could be exposed to radiation, noise, hazardous wastes, or other contaminants or hazards at the remediation site.	This site is a remediation site under CERCLA. Compliance with 29 CFR 1919.120 is required for all sites undergoing remediation by 40 CFR 300.150.
DOT Requirements for Transportation of Hazardous Materials 49 CFR 171-173. 17. 178	No one may transport hazardous materials on public highways except in accordance with these regulations: Part 171 - General Requirements Part 172 - This part establishes shipping papers, marking, labeling, placarding, and emergency response information requirements Part 173 - This part establishes packaging and other shipping requirements for hazardous materials Part 177 - Requirements of the transporter Part 178 - Specifications for shipping containers.	Applicability to those alternatives that involve transportation of the waste materials off site.
Highway Improvement Act of 1982, 23 USC 127	Establishes vehicle weight for interstate highways.	Applicable to off-site transportation of waste materials.
Hazardous Materials Transportation Act, 49 USC 1801-1812	Establishes requirements for minimizing environmental impacts of spills or releases of hazardous materials	Applicable to off-site transportation of waste materials.

Table 7-1d

Potential ARARs - Other Requirements
California Air National Guard - Fresno, California

(Page 2 of 2)

Regulation	Requirement	Implementation
National Historic Preservation Act, USC 470 et. seq.	Protection of sites listed or eligible for listing in the National Register of Historic Places.	It is not likely that any remedial action will impact structures protected by this statute.
Archaeological and Historic Preservation Act, 16 USC 469	Preservation of artifacts and data associated with archaeological finds.	This requirement will be in effect if finds of potential archaeological significance are uncovered during the remediation. There are no present areas of archaeological significance on the site.
American Indian Religious Freedom Act, 42 USC 1996	Provides for tribal access by native peoples to grave sites and sites of cultural, symbolic, or religious significance.	No such areas of significance are known to exist at the present time. Should evidence of such areas be uncovered during remediation, proper notifications must be made.
Native American Graves Protection and Repatriation Act, 25 USC 3001	Provides for the return of human remains and cultural objects from Native American graves to affiliated tribes.	No such grave sites are known to exist at the present time. Should evidence of graves be uncovered during remediation, proper notifications will be made.
Executive Order 11593 - Protection and Enhancement of Cultural Environment	Requires inventory of site for potential historic places for eligibility in the National Register of Historic Places.	This regulation is not anticipated to be applicable at the site.
Fish and Wildlife Coordination Act, 16 USC 66 et seq.	Requires consultation with other state agencies for any activities that might affect any body of water for the purpose of conserving fish and wildlife resources.	The potential remediation activities for this site are not anticipated to significantly impact wildlife.
Archaeological Resources Protection Act, 16 USC 470 (a)	Requires permit for removal of any archaeological resources from federal lands.	If such materials are found, the proper notifications and permit must be obtained.
Antiquities Act and Historic Sites Act 16 USC 431-433 and 16 USC 461-467	Requires identification and preservation of cultural resources on federal lands. Includes natural landmarks.	No such resources have been identified. If during the remediation, such resources are identified, appropriate compliance with this law must be maintained.
Farmland Protection Policy Act, 7 USC 4201 et. seq.	Requires protection and maintenance of farmland for its beneficial use as a national resource.	Required as a matter of law for the site.

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- Initial Screening of Alternatives - To be completed when final remedies are evaluated.

- Draft Comprehensive Listing of ARARs - To be completed upon selection of final remedy.

- EPA and State Review - To be completed once listing of final ARARs has been prepared

- Final Comprehensive Listing of ARARs - Prepared once EPA and state comments have been incorporated.

Preliminary ARARs have been evaluated based on the following RI findings:

- Four sites have been identified on Base property. Soil contamination has been identified at Site 5-BCP. The BCP has been filled to grade with native soil, and no other remedial actions are anticipated in association with the soil media.

- There is no groundwater contamination directly associated with any past site with the exception of Site 5-BCP.

- Some form of groundwater withdrawal and treatment will occur in the future at a point or points to be determined. Treatment processes may include, but are not limited to carbon adsorption, ultraviolet oxidation via ozone or hydrogen peroxide, air stripping with emission controls, and biological oxidation. Extraction wells may or may not be installed for remediation.

7.4.1 Chemical-Specific Requirements

Chemical-specific ARARs are usually health- or risk-derived numerical values that establish an acceptable level or concentration of chemical that may remain in specific environmental media after remediation is complete. These levels are deemed to be protective of human health and are used to help establish remedial cleanup goals (Table 7-1a).

The development of chemical-specific ARARs at this time is limited to the COC identified in this RI report. Chemical-specific ARARs and TBCs have been identified for organic and inorganic chemicals in drinking water. In accordance with the NCP at 40 CFR 300.430(e)(2)(i), the maximum contaminant level goals (MCLG) established under the Safe Drinking Water Act (SDWA) that are above zero shall be attained by the remedial action for groundwater or surface waters that are current or potential sources of drinking water, where the MCLGs are "relevant and appropriate" to the circumstances of the release, as determined

by the factors specified in 40 CFR 300.400(g)(2). If an MCLG is not determined to be "relevant and appropriate," the corresponding MCL shall be attained. When both MCLs and MCLGs exist for a COC, the numerical limits selected for these ARARs are the lower of the nonzero values that are promulgated.

Chemical-specific requirements for the ANG sites include regulations of the SDWA and the Clean Air Act (CAA).

7.4.2 Location-Specific Requirements

Location-specific ARARs generally restrict certain activities, or dictate where certain activities may be conducted, solely because of geographical, hydrologic, or land use concerns.

The location-specific requirements included in this document address those requirements that prevent the selection of an alternative or dictate activities due to special site characteristics. Location-specific requirements considered at this stage included protection of wetlands, endangered species and habitat, areas of historic or archaeological significance, and seismic location and design criteria. There are no wetlands identified nor are there endangered species or habitat within the site or Base. Additionally, there are no historic or archaeological points of interest known to exist on the ANG sites. There are no specific seismic standards that apply, other than standard building code requirements. However, the ANG is located over an aquifer that is considered a sole source aquifer. This status could entail additional review by the state (Table 7-1b).

7.4.3 Action-Specific Requirements

Action-specific ARARs are usually restrictions on the conduct of certain activities or the operation of certain technologies at the site.

Action-specific requirements include both obligatory actions and action limitations. Action-specific requirements include waste management, unit design and operation, and disposal mandated actions and limitations specified in RCRA, Clean Water Act (CWA), and CAA regulations (Table 7-1c).

7.5 Other Requirements

In addition to the types and classes of ARARs described, other requirements exist that are neither ARARs nor TBCs. These other requirements do not fit into the applicable, relevant and appropriate, or TBC categories either because they are not promulgated regulations or

because they are not environmental requirements subject to waiver or negotiation. This latter category includes those requirements such as site worker protection standards under the Occupational Safety and Health Administration (OSHA), and off-site transportation requirements found in the U.S. Department of Transportation (DOT) regulations. An example of nonpromulgated regulations includes the various presidential orders. Other requirements are identified in Table 7-1d to facilitate a thorough evaluation and comprehensive evaluation of the remediation requirements and potential requirements.

7.6 Critical ARAR Determinations

Some ARAR determinations warrant detailed discussion. Detailed discussions of the principal hazardous waste and state ARAR issues are presented in this section.

7.6.1 Hazardous Waste - RCRA

At the present time, no further soil-based remediation is anticipated. If, in the future, additional soil-based remedies are proposed, consideration should be given to the RCRA Subtitle D (nonhazardous) and Subtitle C (hazardous) requirements for treatment, storage, and disposal facilities. These requirements specify the particular requirements needed to construct, operate, close, and monitor a closed RCRA site.

In any event, any waste materials that are generated from remedial activities must be tested to ascertain whether it is a hazardous waste. If it is hazardous, further treatment, storage, or disposal must comply with the requirements of RCRA as administered by the State of California.

7.6.2 More Stringent State Requirements

Those state requirements considered to be ARARs are: (1) promulgated such that they are of general applicability and legally enforceable, (2) identified by the state in a timely manner, and (3) are more stringent than federal requirements (40 CFR 300.400[g][4]). Several State of California promulgated requirements are more stringent than the federal requirements and are potential ARARs for the site; these potential State ARARs are discussed as follows:

7.6.2.1 California Hazardous Waste Regulations

California hazardous waste regulations are codified in Title 22, California Hazardous Waste Management Regulations. These regulations are similar to those in the federal regulations. There are areas that are more stringent. For example, generation quantities for a small

quantity generator are smaller in the California regulations. In developing final ARARs, pertinent specific differences should be clearly identified.

7.6.2.2 California Air Regulations

The California air regulations are considerably different than the federal air regulations under the CAA. To ascertain specific requirements, the California Air Resources Board, San Joaquin Valley Air Basin District office in Fresno should be contacted to discuss specific remediation alternatives, and applicable requirements ([209] 488-4397).

In general, the anticipated remedial activities will involve minor releases of organic chemicals to the air, and viewed as such, air regulations should not pose significant restrictions upon the remediation effort. As a preliminary target, no more than 10 tons per year of organics listed in California Code of Regulations, Title 17, Section 93300 et seq. should be released during the remediation.

7.6.2.3 California Safe Drinking Water Rules

The Fresno ANG Base is located in Fresno County, which is designated as a "sole source aquifer." Because of this, the California Water Resources Control Board, Central Valley Region, should be contacted to discuss special considerations that the state may have with regard to protecting this resource.

7.6.2.4 California Water Quality Standards

California water quality standards include maximum concentration limits published in Title 22, California Drinking Water Quality Standards, Section 64444.5. These are summarized with the federal MCLs and MCLGs in Table 7-1a. The more stringent requirement should govern. The state standard for carbon tetrachloride is very stringent, at 0.5 µg/L, and further discussions with the state may be necessary relative to the applicability of this MCL in any further remediation.

8.0 Contaminant Fate and Transport

A number of organic compounds were detected in soil and groundwater at Site 5-BCP due to the site investigation and RI sampling at this site. Fate and transport processes and mechanisms for each site under consideration are developed in this section in support of the risk assessment (Chapter 9.0).

In general, chemicals are expected to migrate in the environment due to various physico-chemical processes; thus, it is essential to evaluate the fate and transport of the compounds detected at the various sites. This chapter evaluates the fate and transport properties of the detected compounds by describing the potential routes of migration, physical characteristics of the site, physical and chemical properties of the compounds, and the environmental processes that affect chemical migration. Each compound that was detected is summarized; actual COC are fully developed in Chapter 9.0.

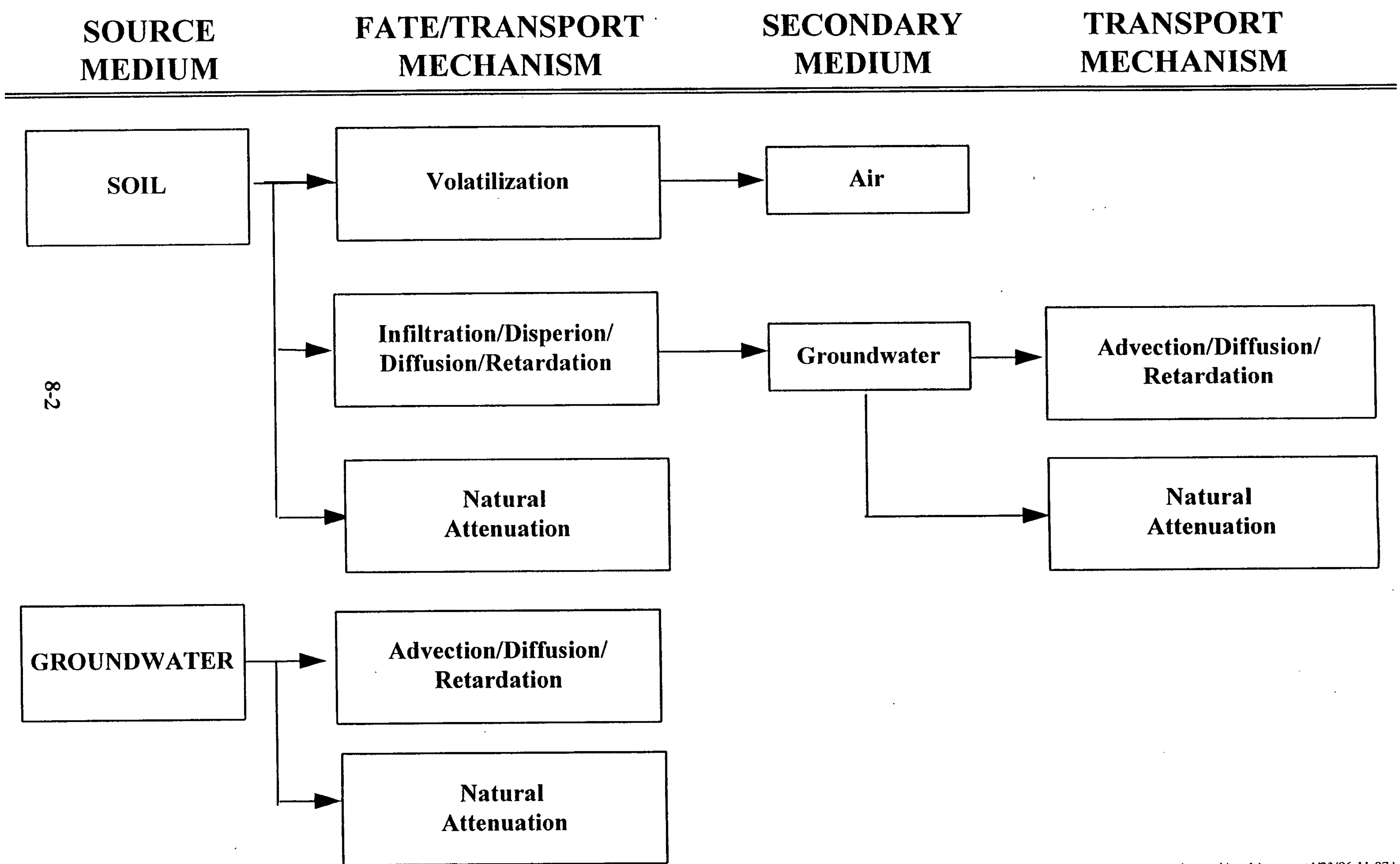
8.1 Potential Routes of Migration

Presented in Figure 8-1 is the conceptual fate and transport model that illustrates the dominant transport mechanism for chemicals in soils and groundwater to migrate off site. As shown in Figure 8-1, chemicals in soil may migrate to groundwater via water infiltration, dispersion, and diffusion. Infiltration of compounds in soil is predominantly precipitation driven and is the dominant transport mechanism for contaminant migration to groundwater. Diffusion, dispersion, and retardation of chemicals are determined by the physical and chemical properties of the compounds and soils. The predominant transport mechanism for compounds in groundwater is advection. Dispersion and diffusion are second-order transport mechanisms, with soil adsorption being the phenomenon responsible for slowing down contaminant migration. Adsorption to soil results in the retardation of the contaminant migration velocity. In general, compounds in groundwater will be transported downgradient with groundwater flow; however, trace amounts of the compounds may diffuse up gradient.

8.2 Contaminant Persistence in the Environment

Chemical persistence in environmental media is determined by the chemical's ability to move through a medium, to transfer from one medium to another, and to transform or degrade. This in turn is controlled by the characteristics of the chemicals (e.g., solubility, volatility, density, and affinity for organic and inorganic surfaces) and of the environmental medium (i.e., mineralogy, organic carbon content and porosity of the soil, and temperature and salinity

Figure 8-1
Conceptual Fate and Transport Model
Fresno Air National Guard



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of groundwater). The migration and persistence for various compounds found in the soil/groundwater system is discussed in the following subsections. Presented in Table 8-1 are the physical and chemical characteristics of various organic compounds detected in Site 5 soils and groundwater. All values in Table 8-1 are from EPA (1994b) and are based on extensive literature review. Due to the wide range of values for certain compounds, whenever present, the geometric mean of each chemical-specific parameter is used, because it is the best estimate of the central tendency value (EPA, 1994b).

8.2.1 Media-Specific Persistence

Migration of chemicals from soil to groundwater is generally reduced by high organic content in the soil, lower temperatures, and higher salinity in the soil-water compartment. The fraction of a chemical present in the soil-water and soil-air compartments is generally more mobile than the fraction adsorbed to soil. Many chemicals, both organic and inorganic, tend to adsorb more readily in top soil than at depth because the organic carbon content is generally lower in deep soils. Soil organic matter is a poorly defined, polymerized network of organic compounds resulting from plant and animal residues. Because the polymers are composed of functional groups such as carboxylic acids, phenols, and ammonia groups that have acid dissociation constants (pK_a), pH dependent adsorption sites are present that are capable of immobilizing both inorganic and organic polar compounds. The polymers also contain nonpolar functional groups that immobilize nonionic compounds (Suffett and MacCarthy, 1989).

8.2.2 Chemical-Specific Persistence

Volatile organic chemicals in soil, especially in the soil-air compartment or in the soil near the surface, can migrate via diffusion through soil-air pore spaces to the ground surface, where they are then transported by wind. Migration of chemicals from soil to air is controlled by the volatility and mobility of the chemical. Chemicals with high volatility but low mobility, because of high soil adsorption, will not migrate significantly to air. Similarly, chemicals with high mobility but low volatility will not partition significantly to air. The volatility of a compound may be inferred from its Henry's law constant (H). As H increases, the volatility of a compound increases; thus, from Table 8-1, TCE is more volatile than cis-1-2-DCE. The capacity for an organic chemical to adsorb to soils may be inferred from its organic carbon partition coefficient (K_{oc}). A high K_{oc} indicates a high adsorption potential.

Chemicals in the environment may degrade through chemically or biologically mediated processes. The primary chemical degradation processes in the soil-groundwater system are

Table 8-1

Chemical Parameters Affecting Environmental Transport and Persistence[a] California Air National Guard - Fresno, California

(Page 1 of 2)

Compound	K_{ow} (unitless)	K_{oc} (mL/g)	H (atm-m^3/mol)	Water Solubility (mg/L)
Acetone	0.57	0.36	2.88×10^{-5}	Infinitely Soluble
Benzo(b)fluoranthene	3.72×10^{6}	2.34×10^{6}	6.17×10^{-6}	4.33×10^{-3}
Benzo(k)fluoranthene[a]	6.92×10^{6}	4.36×10^{6}	3.87×10^{-5}	Virtually Insoluble
bis(2-Ethylhexyl)phthalate	2.00×10^{5}	1.26×10^{5}	8.36×10^{-6}	0.39
Carbon tetrachloride	525	164	2.88×10^{-2}	792
Chloroform	1.95	1.75	4.0×10^{-3}	7960
Chrysene	4×10^{5} [b]	2.52×10^{5}	1.21×10^{-6}	4.33×10^{-3}
1,2-Dichloropropane (1,2-DCP)	117	47	1.37×10^{-1}	1.5×10^{-1}
cis-1,2-Dichloroethene (cis-1,2-DCE)	48[c]	29[c]	4.51×10^{-3}	4940
trans-1,2-Dichloroethene (trans-1,2-DCE)	96[c]	50[c]	9.4×10^{-3}	8030
Diethyl phthalate	912	575	5.47×10^{-7}	883
Di-n-butyl phthalate	2.69×10^{4}	1568	1.43×10^{-6}	10.8
Fluoranthene	2.14×10^{5}	1.35×10^{5}	6.5×10^{-6} [a]	0.23
Indeno(1,2,3-cd)pyrene	4.57×10^{7}	2.88×10^{7}	5.47×10^{-8}	1.07×10^{-2}
Methylene chloride	17.8[b]	11.2	2.4×10^{-3}	17,400

Table 8-1

Chemical Parameters Affecting Environmental Transport and Persistence[a] California Air National Guard - Fresno, California

(Page 2 of 2)

Compound	K_{ow} (unitless)	K_{oc} (mL/g)	H (atm-m^3/mol)	Water Solubility (mg/L)
Pyrene	1.51×10^5	9.51×10^4	2.68×10^3	1.3×10^{-5}
Tetrachloroethene (PCE)	357[c]	300[c]	1.7×10^{-2}	232
Trichloroethene (TCE)	271	94[c]	1.1×10^{-2}	1180

[a] Unless otherwise stated, all data are from EPA, RREL.

[b] U.S. Environmental Protection Agency (EPA), 1992, ***Dermal Exposure Assessment: Principles and Applications***, Interim Report. EPA/600/8-91/011B.

[c] U.S. Environmental Protection Agency (EPA), 1994b, ***Risk Reduction Engineering Laboratory (RREL), Cincinnati, Ohio Treatability Database***, Version 4.0.

Kow - octanol/water partition coefficient
Koc - organic carbon/water partition coefficient

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hydrolysis and oxidation/reduction. Vapor-phase chemicals may degrade by photolysis and photochemical oxidation. Organic chemicals in soil and groundwater may also be degraded by aerobic and/or anaerobic bacteria. This degradation is affected by nutrient levels, temperature, chemical concentration, and the density of degrading organisms.

The mobility of organic compounds within the saturated zone is affected by chemical processes that are in part dependent on their volatility, the octanol-water partition coefficient (K_{ow}), water solubility, and concentration. In general, the more water insoluble an organic compound is, the more hydrophobic it is, and the more likely it is to be absorbed on a sediment or organic surface. These compounds also have a tendency toward self-association in a polar medium such as water. Hydrophobic compounds tend to have a higher K_{ow} and a greater affinity to organic matter contained within the sediment matrix. Compounds such as acetone and the chlorinated aliphatic hydrocarbons with high aqueous solubilities also have relatively low K_{ow}s. Migration of these compounds in groundwater, at low concentrations, tends to be more rapid than other compounds (e.g., phthalates, pesticides, or large aromatic compounds with low solubilities and high K_{ow}s [Table 8-1]). Even compounds with relatively low K_{ow}s will, however, exhibit some attenuation if the organic content of the soil/aquifer matrix is high.

For several groups of compounds (including phenols, phthalates, and monocyclic aromatics [benzene, toluene, and xylene]), volatilization, sorption, and biodegradation are all prominent processes. Generally, in surface waters volatilization dominates, whereas in the subsurface environment biodegradation or sorption will dominate depending on the amount of natural humic material in the receiving soils and the availability of oxygen.

The behavior of polyaromatic hydrocarbon (PAH) (e.g., chrysene) is a function of the number of rings present. It appears that the important processes for these compounds are sorption, sedimentation in surface water associated sediments, and both aerobic and anaerobic biodegradation.

Biotransformation in shallow aquifers has also been demonstrated. Recent studies have shown that biodegradation occurs for some compounds under aerobic and/or anaerobic conditions (Bouwer, 1994; Vogel, 1994). Chemicals in this class include PCE, pentachlorophenol, toluene, xylene, and phenolic compounds.

8.3 Site-Specific Contaminant Migration

Migration of organic compounds in soils and groundwater are discussed in this section. Base-specific groundwater background sampling results are also analyzed to establish background levels for some organic compounds. The fate and transport of compounds are evaluated based on summary statistics of analytical results. These statistics comprise mean, standard deviation, range of detections, and detection frequencies for all the detected compounds and include samples taken during the SI (IT, 1992a), the RI (IT, 1993b), and quarterly groundwater monitoring program (IT, 1993c). For statistical reporting, one-half the detection limits were assigned to nondetect values. Compounds with no detections are not included in the summary tables.

8.3.1 Migration Potential in Soils

Migration of organic compounds from soil to groundwater, or air is discussed in the following paragraphs. The groundwater table is approximately 80 feet bgs.

Site 5-BCP. Site 5-BCP no longer exists as it did during the SI and RI. Currently, it is filled to grade and will be covered with concrete and/or asphalt by the year 2006. The effect of additional soil and cover on contaminant migration at this site will significantly reduce precipitation-driven infiltration of contaminants in surface and subsurface soils. Thus, it may be concluded that organic compounds in soils at Site 5-BCP are highly unlikely to transport to groundwater after asphalt or concrete is in place.

A summary of organic compounds detected in surface and subsurface soils is presented in Table 8-2. All the compounds detected in surface soils at Site 5-BCP are VOCs or SVOCs. These compounds in the soil-air compartment or in the soil near the surface are most likely to migrate via diffusion through soil-air pore spaces to the ground surface, where they are then able to be transported by wind. Thus, they are highly unlikely to migrate to the groundwater table. The distance to the groundwater table and the arid conditions of the region further reduce the likelihood of migration of these compounds to the groundwater. Also, organic compounds detected in surface soils were not detected in Site 5-BCP groundwater (discussed later in this chapter), indicating that these compounds are present only in the soil column.

Laboratory analysis of deep soils resulted in the detection of acetone, bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, diethyl phthalate, methylene chloride, and TCE. It is likely that these compounds, except for TCE, are related to sampling and analysis equipment and are not associated with actual contamination (see Chapter 6.0). The fact that deep soil

Table 8-2
Summary Statistics on Organic Compounds Detected in Site 5-BCP Soils
California Air National Guard - Fresno, California

Compound	Mean[a] (µg/kg)	Std. Dev.[a] (µg/kg)	Range of Detected Concentrations		Detection Frequency[c]	Detection Percent
			Min[b]	Max		
Surface Soils[d]						
Acetone	9.6	7.1	4	24	1/9	11.1
Benzo(a)pyrene	181.2	32.1	100	210	1/9	11.1
Benzo(b)fluoranthene	167.5	53.7	37.5	210	1/9	11.1
Benzo(k)fluoranthene	167.6	53.4	38.5	210	1/9	11.1
bis-(2-Ethylhexyl)phthalate	166.6	36.4	89	200	3/9	33.3
Chrysene	182.8	29.0	110	210	1/9	11.1
Diethyl phthalate	179.3	45.7	59	210	1/9	11.1
Fluoranthene	174.1	36.6	97	210	2/9	22.2
Indeno(1,2,3-cd)pyrene	162.4	59.2	40	210	2/9	22.2
Methylene chloride	8.0	2.0	3.5	10.5	1/9	11.1
Phenanthrene	176.3	47.6	52	210	1/9	11.1
Pyrene	155.1	54.1	50	200	3/9	33.3
Deep Soils[e]						
Acetone	99.0	116.4	11.5	300	4/7	57.1
bis(2-Ethylhexyl) phthalate	812.8	1997.9	41	11000	19/49	38.8
Di-n-butyl phthalate	214.7	117.8	47	1000	1/49	2.0
Diethyl phthalate	239.2	178.8	175	1400	4/49	8.2
Methylene chloride	9.0	12.1	0.9	85	3/45	6.7
TCE	1.0	1.1	0.1	5	2/49	4.1
Deep Soil Screening Samples[f]						
trans-1,2-DCE	26.4	10.7	25	111	1/64	1.6
cis-1,2-DCE	25.6	5.1	25	66	1/64	1.6
TCE	52.0	72.7	25	410	12/64	18.8
PCE	70.3	107.6	25	640	18/64	28.1

[a] Utilizing one-half the detection limit for nondetect values.
[b] Generally represents one-half of the lowest reported detection limit.
[c] Number of samples includes field duplicates.
[d] From samples collected during the SI (IT, 1992a).
[e] From focused RI (Section 6.2).
[f] Includes screening samples from only SB5-03 through SB5-07, which are located at the bottom of the Base Collection Pond.

samples were taken close to groundwater suggests that the presence of TCE in deep soils is most likely due to volatilization from groundwater. However, they are discussed here for completeness. Fate and transport properties of acetone were previously discussed. This compound is likely an artifact of laboratory contamination.

bis(2-Ethylhexyl)phthalate strongly adsorbs to soil, making this compound relatively immobile. Low water solubility and low volatilization potential also reduce its mobility. Both in shallow and deep soil, virtually all bis(2-ethylhexyl)phthalate is adsorbed to soil; therefore, it is not available for migration. Although the persistence of bis(2-ethylhexyl)phthalate is not well documented, it is generally expected to persist for months or years (National Laboratory of Medicine [NLM], 1991). Direct photolytic degradation in air does not occur. Di-n-butyl phthalate degrades within months under both aerobic and anaerobic conditions. Degradation of this compound is likely because anaerobic degradation occurs readily in soil. Diethyl phthalate may be very persistent in the environment. In soil, aerobic biodegradation occurs, perhaps fairly rapidly, but measurements of the rate of this degradation are highly variable. Diethyl phthalate's low K_{oc} and water solubility indicates that it is highly immobile in the soil column and tends to adsorb readily.

Also presented in Table 8-2 is a summary of screening sample analyses that were used to identify soil samples to be submitted for confirmation (laboratory) analyses. VOCs detected were cis- and trans-1,2-DCE, TCE, and PCE. From their physical properties, low K_{oc} and high water solubility, it can be inferred that these compounds are mobile and, therefore, under favorable conditions may infiltrate to groundwater. However, the physical constraints at the site, such as distance to groundwater and arid conditions, limit the migration potential of these compounds. Thus, it is highly unlikely that a significant fraction of these compounds will reach the groundwater table before the cover is instituted. As previously noted, once the cover is installed, migration to groundwater will be unlikely to occur.

8.3.2 Migration Potential in Groundwater

Chemical constituents detected in groundwater samples are presented in Section 6.0, specifically, Tables 6-1, 6-2, and 6-5 through 6-8. Table 6-1 presents a summary of organic compounds detected in upgradient Base perimeter monitoring wells. Table 6-7 presents a summary for downgradient Base perimeter wells and Tables 6-2 and 6-5 contain constituents found in Site 5-BCP groundwater samples. Table 6-6 summarizes the detections for each water table monitoring well on Base property.

Site 5-BCP and Downgradient Base Perimeter. A comparison of results for upgradient versus downgradient wells (Tables 6-1 and 6-7) show a decrease in concentration for TCE and 1,2-DCP. This decrease is attributed to dispersion, dilution, and other attenuation processes. The predominant site-related chemical of concern is PCE, with minor detections of chloroform and cis-1,2-DCE. All three of these compounds are relatively mobile in groundwater, with cis-DCE and chloroform having medium to high water solubility. Therefore, these compounds would be expected to migrate downgradient with groundwater flow.

There is evidence suggesting that PCE has the potential to undergo biodegradation in an anaerobic groundwater environment. It is conceivable that PCE may degrade before it migrates a significant distance downgradient. However, TCE, a daughter compound of PCE, is measured in groundwater at somewhat elevated concentrations almost a half-mile downgradient from its suspected point of origin. This suggests that the breakdown of TCE is not occurring at a rapid pace. If this discussion is applied to PCE, then PCE has the potential to be present at detectable levels for some distance. However, degradation of PCE would possibly lead to the formation of TCE (Vogel, 1994); thus, the residuals of PCE could persist in groundwater for a long time over a large distance.

8.4 Summary

8.4.1 Groundwater

TCE and 1,2-DCP were found in Base-specific background wells at significant levels, indicating an off-Base source for these compounds. cis-1,2-DCE and PCE were detected in Site 5-BCP groundwater and are considered to be site-related. cis-1,2-DCE, trans-1,2-DCE, PCE, and TCE were found in Site 2 groundwater, but are not specifically related to Site 2. 1,2-DCP, cis-1,2-DCE, and trans-1,2-DCE are expected to migrate with groundwater at the Base. PCE concentrations in groundwater are expected to decrease with time due to natural attenuation; therefore, it is likely that only trace amounts of PCE will migrate any significant distance downgradient. However, if PCE degrades, it would result in the formation of TCE, as discussed in Section 8.3.2.

8.4.2 Soils

VOCs and SVOCs in soils are not expected to migrate to groundwater due to a combination of some, or all, of the following reasons:

- Arid conditions at the Base significantly reduce the precipitation driven infiltration of compounds.

- Volatile compounds are likely to migrate via diffusion through soil-air pore spaces to the ground surface, where they are then transported by wind.

- Before organic compounds reach groundwater, they are likely to be attenuated by biodegradation.

- Distance to groundwater allows for chemical retardation, dilution, diffusion, and degradation (both chemical and biological) processes that will inhibit the downward migration.

9.0 Baseline Risk Assessment Summary

A baseline risk assessment is an analysis of the potential adverse effects (current and future) caused by the release of hazardous substances from a site in the absence of any actions to control or mitigate the release(s) (i.e., under an assumption of no action). The baseline risk assessment contributes to the site characterization and subsequent development, evaluation, and selection of appropriate response alternatives. The results of the baseline risk assessment provide the basis for determining whether or not remedial action is necessary and the justification for performing remedial actions at a site.

Objectives of the baseline risk assessment were to:

- Characterize the chemical sources and determine chemicals of potential concern (COPC) for sites present within the Base area.
- Evaluate transport of chemicals from the source to potential exposure points.
- Identify potential receptors and quantify potential exposures under current and future conditions.
- Characterize the potential baseline risks associated with the Base area under current and future conditions.
- Evaluate potential risks to ecological populations in the Base area.

The baseline risk assessment was performed according to EPA guidance and reference the baseline risk assessment work plan (IT, 1995b). Summary and conclusions of the risk assessment are presented in the following sections. The entire baseline risk assessment document is found in Appendix J.

9.1 Summary

Site 5-BCP soils and groundwater were evaluated. In addition, groundwater entering and leaving the Base was evaluated to determine the contaminant contribution (if any) by the Base as a whole.

COPC were selected in soil and groundwater for Site 5-BCP and for groundwater upgradient and downgradient of the Base. Selection of COPC was based on the criteria described in the baseline

risk assessment work plan. COPC evaluated in the risk assessment for soil and groundwater in different sites were as follows:

- Soil
  - Site 5-BCP - PAHs, TPH, bis(2-ethylhexyl)phthalate, diethyl phthalate, acetone, cis-1,2-DCE, trans-1,2-DCE, PCE, TCE, and methylene chloride.
- Groundwater
  - Site 5-BCP - PCE and TCE.
- Upgradient Perimeter Water Table Wells (MWBP-01, -02, -03, -04, -09, and -10)
  - TCE, 1,2-DCP, carbon tetrachloride, diethyl phthalate, and di-n-butyl phthalate.
- Downgradient Perimeter Water Table Wells (MWBP-05, -06A, -07, -08, -11, -12)
  - PCE, TCE, 1,2-DCP, chrysene, cis-1,2-DCE, and bis-(2-ethylhexyl)phthalate.

Groundwater along the northern Base boundary (i.e., upgradient perimeter wells) contains chlorinated organics, indicting an upgradient, off-site source of contamination. An area-specific background range has been calculated, taking into consideration the off-site contamination (Section 6.1, Table 6-1) to determine the impact to groundwater from the Base itself. Because several of the reported compounds are present in upgradient groundwater, they are not considered to be previously associated with site facilities. Site 5-BCP is directly downgradient of the northern Base boundary. The following volatile organic compounds, therefore, are not considered to be related to past ANG activities at Site 5-BCP: carbon tetrachloride, 1,2-dichloropropane, and TCE.

Reasonable maximum exposures (RME) were evaluated for all exposure pathways. Central tendency (CT) exposure scenarios were evaluated for those pathways where the adult RME risk estimates were above the acceptable limit as mandated by the EPA. Only the RME scenario was evaluated for the residential child, because the default exposure parameters for the RME child and the central tendency exposure scenario are the same. Therefore the estimated risks for both scenarios would be the same. In addition, only noncarcinogenic hazards were evaluated for the residential child, given that carcinogenic risks for the adult scenario would be larger than the default parameters used in estimating the cancer risks. Exposure pathways considered for these scenarios were as follows:

- Soil
  - Inhalation of volatiles.

- Groundwater
  - Ingestion
  - Dermal contact during household use
  - Inhalation of volatiles during household use.

Potential receptors that were evaluated were the future resident near the Base, a construction worker on Base, Base personnel working outdoors, and Base personnel working in a building located at Site 5-BCP.

Risk assessment results are presented in the baseline risk assessment (Appendix J). Cancer risk estimates for on-site receptors (construction workers and Base personnel) exposed to volatile organic vapors in soils at Site 5-BCP are below the lower limit of the target risk range of 10^{-6} to 10^{-4}. The cancer risks for contaminants leaching into groundwater, (based on both modeled and measured concentrations) were within or below the acceptable range of 10^{-6} to 10^{-4}. Also, all noncarcinogenic hazard indices (HI) associated with contaminants at Site 5-BCP, were below the acceptable limit of one (1.0). Therefore, risk estimates for exposure to Base soils are not presented or discussed further. Significant chemicals, pathways, and corresponding cancer risks and HIs for groundwater are summarized in Table 9-1 and discussed in the following paragraphs, because several estimates exceed the acceptable limits.

When cancer risk estimates for the upgradient wells are compared with estimates for the site and downgradient wells, certain observations may be made for the residential ILCRs:

- RME cancer risks for the upgradient wells exceed the acceptable range, due largely to TCE and 1,2-DCP.

- RME cancer risks for the downgradient wells exceed the acceptable range, due largely to PCE and TCE.

- CT cancer risks for both upgradient and downgradient wells are within the acceptable range of 10^{-6} to 10^{-4}.

Table 9-1

Summary of Significant RME Risk Results
California Air National Guard - Fresno, California

Pathway	Upgradient Wells	Downgradient Wells
Groundwater: Measured Concentrations (Adult RME)		
Cancer Risk		
Ingestion	TCE: 9.2×10^{-5} DCP: 9.6×10^{-6} CT: 1.4×10^{-6}	None
Dermal Contact	None	None
Inhalation of Volatiles	TCE: 2.3×10^{-4} PCE: 3.6×10^{-5} CT: 5.3×10^{-6}	PCE: 1.0×10^{-4} TCE: 1.8×10^{-5} DCP: 1.1×10^{-5}
Noncancer Risk		
Ingestion	TCE 2.4	None
Dermal Contact	None	None
Inhalation of Volatiles	TCE: 8.9 DCP 1.2	PCE: 1.1 TCE: 0.7
Groundwater: Measured Concentrations (Child RME)		
Cancer Risk		
Ingestion	None	None
Dermal Contact	None	None
Inhalation of Volatiles	None	None
Noncancer Risk		
Ingestion	TCE: 5.5	PCE: 0.7 TCE: 0.4
Dermal Contact	None	None
Inhalation of Volatiles	None	None
Central Tendency Hazard Index		
Ingestion	TCE: 1.8	None
Dermal Contact	None	None
Inhalation of Volatiles	TCE: 6.1	PCE: 0.8 TCE: 0.5 DCP: 0.3

PCE = Tetrachloroethene
TCE = Trichloroethene
DCP = 1,2-Dichloropropane
CT = Carbon tetrachloride.

- Cancer risks for the upgradient wells exceed cancer risks for the site wells and the downgradient wells.

- PCE appears to be the only significant contaminant derived from site activities (specifically Site 5-BCP).

A similar comparison of the noncancer residential HIs reveals the following:

- The HIs from constituents measured and modeled in groundwater at Site 5 are below 1.0.

- The RME HIs for the upgradient wells are over an order of magnitude above the acceptable limit. The primary risk drivers are TCE and 1,2-DCP for adult and TCE for child.

- The RME HIs for the downgradient wells are above the acceptable limit. None of the chemicals had HIs above 1.0; however, the total HI exceeded 1.0. PCE and TCE were the major risk drivers for both the adult and child resident receptor.

- The CT HIs for upgradient and downgradient wells are above the acceptable limit for the adult residential receptor. The drivers are TCE and PCE in both cases.

- The HIs for upgradient wells are always greater than HIs associated with the downgradient wells.

Exposure of ecological receptors at Site 5-BCP is limited to inhalation of volatile organics migrating to the surface from subsurface soils. Based on the poor habitat present at the site and the future construction which is likely to remove all potential wildlife habitat, potential exposure of ecological receptors is expected to be minimal. With the absence of any viable potential exposure pathways, ecological receptors are not likely to be adversely affected by contaminants associated with Site 5-BCP or the Base.

9.2 Conclusions

Groundwater at the Base is lightly contaminated by organic constituents. Primary contributors to cancer risk are TCE and PCE. Based on the comparison of risks from upgradient and down-gradient Base perimeter wells, it may be concluded that PCE is the only significant contaminant in groundwater derived from the Base activities. The total risk from downgradient Base perimeter wells is less than the total risk from upgradient Base perimeter wells, in part due to lower concentrations of TCE and 1,2-DCP in downgradient wells.

Risks and hazards from exposure to contaminants in soil at the Base are below the target risk range mandated by EPA. This includes inhalation of volatile organics by on-site receptors and exposure to off-site residents via leaching of contaminants into groundwater.

There is minimal potential risk to ecological receptors from contaminants in either soils or groundwater.

It is concluded that exposure to groundwater both upgradient and downgradient of the Base poses a potentially unacceptable cancer risk under the RME scenario, however the CT risks are within the acceptable range. Groundwater upgradient and downgradient of the site poses an unacceptable systemic or noncarcinogenic risk to residential receptors. The potential risks to human health from groundwater decrease as the groundwater migrates across the Base.

10.0 Summary and Conclusions

10.1 Summary

10.1.1 Site 5-BCP Investigation

The Site 5-BCP investigation was conducted in 1992. As a part of the RI at Site 5-BCP, an SOV survey was conducted across the western portion of the Base, 12 soil borings were drilled and sampled in and near Site 5-BCP, more than 160 soil screening samples were analyzed for VOCs in a field laboratory, 7 groundwater screening samples, and 41 confirmation soil samples were analyzed at a fixed-base laboratory. In addition, two monitoring wells were installed at Site 5-BCP and four wells were installed along the Base perimeter. In 1995, the BCP was filled to grade with soil in preparation for converting it to the new Base POL facility by the year 2006. The BCP no longer exists as it did when the investigation occurred. The decision for allowing Site 5-BCP to be filled in was based on an evaluation of investigation results initially presented in the RI (IT, 1993b) and in more detail in this report.

Results of the SOV survey reported no positive detections. Therefore, they provided no guidance with which to focus the location of soil borings during confirmation activities. Soil screening samples detected low concentrations of PCE in approximately 30 percent of the samples, and TCE in approximately 20 percent of the samples collected within the extent of the former BCP. Confirmation soil sample analyses did not report any PCE or TCE concentrations. Based on the discussion in Section 6.2.3, the screening analysis results are considered more indicative of actual subsurface soil conditions than the confirmation analytical results. Soil screening results indicate that Site 5-BCP may have been a contributor of PCE to the shallow groundwater system. TCE may also have been introduced through Site 5-BCP, but at much lower concentrations. Current concentrations of VOCs in the soil show that they are in a residual, immobile state. Future leaching of VOCs to groundwater is not expected and will be precluded by the elimination of future infiltration by Site 5-BCP having been filled to grade in 1995.

Groundwater samples collected around Site 5-BCP indicate that the former BCP is a likely source for PCE contamination. Current groundwater concentrations of PCE around Site 5-BCP are in the 20-µg/L range. Higher concentrations are measured downgradient, suggesting that the major mass of PCE has migrated downgradient. TCE concentrations in the vicinity of Site 5-BCP are lower than nearby wells, indicating a dilution effect. While Site 5-BCP was in service, it provided a source of recharge to local groundwater and probably caused a

groundwater mound in the immediate area. This recharge diluted TCE contaminant concentrations in the underlying groundwater. This suggests that TCE was not introduced through Site 5-BCP at any significant concentration and that the TCE measured in Site 5-BCP soils is likely present as a result of decay/degradation of PCE.

Soil samples were also analyzed for SVOCs and TPH-d, and groundwater samples were analyzed for SVOCs and pesticides/PCBs. No significant detections of any of these groups of compounds were reported.

Low concentrations of PCE in soil screening samples indicate that contamination is residual in nature. PCE concentrations in groundwater near Site 5-BCP show either stability or a slightly decreasing trend. This also suggests that Site 5-BCP is no longer an active source area.

10.1.2 Shallow Groundwater Activities

A quarterly groundwater sampling program was initiated in June 1992 and concluded in April 1993. Site 5-BCP wells and four additional Base perimeter monitoring wells were installed prior to the second quarterly sampling event, and so they were only sampled in three of the four events.

Groundwater samples collected along the upgradient Base perimeter show a consistent presence of TCE in shallow groundwater. TCE in shallow groundwater is caused by a source area located 2,500 feet upgradient of Base property as shown in Figure 2-3 (ERM, 1992; 1994).

Samples from Site 5-BCP show the first occurrence of PCE on Base and they provide more detailed information on the effects of recharge on TCE contaminant concentrations. PCE is also measured in downgradient wells at higher concentrations, indicating (1) that the majority of PCE in groundwater has migrated off Base property and (2) that Site 5-BCP is not a continuing source area for groundwater contamination. The conclusion that Site 5-BCP is no longer a source of PCE is corroborated by data trends over the sampling time period.

Concentrations of PCE in both Site 2 and Site 5 wells have decreased slightly over the sampling period. This is also true of PCE concentrations in downgradient well MWBP-05. Decreasing PCE levels near the source area support the conclusion that no more PCE is being introduced into groundwater.

Conversely, TCE concentrations in groundwater have remained relatively stable during the sampling program. Average upgradient concentrations are higher than average downgradient concentrations. A combination of attenuation mechanisms, such as dilution, degradation, and sorption, is responsible for the observed decreases with downgradient location. Additionally, vertical migration of TCE will cause increases of concentrations with depth, but decrease concentrations at the water table.

10.1.3 Deep Aquifer Investigation

The deep aquifer investigation was tasked with determining the vertical extent of groundwater contamination across the western portion of the Base. This task began in 1993 with the exploratory boring program and concluded in 1995 with aquifer tests. The deep aquifer investigation consisted of drilling five exploratory boreholes to a depth of 250 feet bgs, collecting groundwater and soil screening samples, performing geophysical logging, and designing and installing a deep aquifer monitoring well network. Two rounds of groundwater samples were collected from the eight deep wells in December 1993 and February 1995. Aquifer tests, consisting of a step-drawdown and constant rate discharge test, were conducted in two monitoring wells in March 1995. A total of five piezometers were installed in support of these tests.

Exploratory borings were drilled with rotary sonic drilling techniques that provided a continuous core of subsurface material. Geophysical logs complimented and confirmed the use of this drilling technology for geologic logging purposes.

A total of 28 groundwater screening samples were collected to depths of 250 feet bgs in the exploratory borings. Screening sample data and geologic information provided by the exploratory borings allowed for designing the deep monitoring well network. Groundwater screening data indicated that PCE was the only contaminant that could be directly attributed to past ANG activities. PCE was only detected above depths 130 feet bgs, whereas TCE was detected at 250-foot depths in two of the five borings. Monitoring wells were installed to provide contaminant information within and below PCE contamination.

Groundwater sample data from the deep wells confirm that PCE is not present in deeper saturated sediments. PCE was also not detected in upgradient monitoring wells. TCE is present in intermediate-depth (B zone) and deeper (C zone) wells.

Detailed geologic information was obtained from the logs of the exploratory borings. Cross sections showing the geologic setting and interpreted hydrogeologic framework are included in Section 5.3. The alluvial aquifer comprises a series of heterogeneous aquifers that are separated to some degree by discontinuous aquitards. Monitoring wells have been installed into the water table (A1 aquifer), the lower portion of the A1 aquifer, and the A2 aquifer.

Aquifer tests conducted in a water table well and in a B series (lower A1 aquifer) well demonstrated that measurable cones of depression can be created by inducing a stress on the aquifer. However, areas of influence are small relative to the areal extent of the PCE plume, and a number of wells would be required to prevent downgradient migration. As suggested in Section 10.1.2, the majority of the mass of PCE has likely migrated off of Base property; thus, installing extraction wells on Base would only address the trailing end of the plume and would not affect off-Base areas. Aquifer tests also showed that the water table and B zones are connected and can be considered one aquifer, which is designated the A1 aquifer.

10.2 Conclusions

10.2.1 Site 5-BCP

The objectives of the Site 5-BCP investigation (Section 4.2) were accomplished through the program that is summarized in Section 10.1.1:

- A more detailed description of the vadose zone was provided at Site 5-BCP. The cross section of the unsaturated zone showed the presence of thin cemented layers and sporadic wetting fronts that eventually recharge the local water table.

- Subsurface contamination was confirmed at Site 5-BCP with the use of field GC screening techniques. Soil screening analyses showed the presence of VOCs, primarily PCE and TCE, in subsurface soils. Infrequent detections of other related chlorinated VOCs were also reported. Concentrations and their distribution pattern indicate that contaminants are residual in nature and are expected to be immobile. TCE and PCE were detected only once at a depth of 10 feet below the bottom of Site 5-BCP. Below this depth, they were detected at 20 and 25 feet, and more frequently with depth. This shows that the contaminants have been leached to deeper portions of the vadose zone and that the initial source for PCE into Site 5-BCP was discontinued long ago. Concentrations of PCE in groundwater are greater in downgradient wells than in wells in the immediate vicinity of Site 5-BCP, thereby suggesting that the majority of PCE has already been introduced to groundwater and that no further significant influx has occurred in the recent past. Due to Site 5-BCP being filled to grade and storm runoff being rerouted away from Site 5-BCP, no more large volume infiltration will occur through the soil. This greatly reduced potential for

infiltration through Site 5-BCP will preclude any further leaching of contaminants.

- Risk estimates of construction worker exposure to soil at Site 5-BCP were all within or less than the acceptable range of 10^{-6} to 10^{-4}. Therefore, no unacceptable risk associated with soil exists.

- The nature and extent of contamination in soil was characterized. Contaminants were determined to be limited to VOCs and the vertical extent of VOC contamination was defined to be near the water table. As previously summarized, the source for PCE was discontinued long ago such that the VOCs are in a residual, immobile state.

- The source of PCE contamination in groundwater was at one time Site 5-BCP. This site is no longer considered to be an active source area. Decommissioning Site 5-BCP from its past use removes it from IRP Site status. Its legacy, PCE groundwater contamination, will be addressed in the future.

10.2.2 Shallow Groundwater

The quarterly groundwater sampling program provided information on the variability of contaminant concentrations in water table wells over the sampling period:

- TCE and 1,2-DCP are frequently detected in upgradient Base perimeter wells. TCE is also present along the southern (downgradient) extent of Base property. Concentrations across the western portion of the Base have stayed relatively consistent from one time to the next. However, concentrations decrease as they migrate across Base property. An upgradient off-site source area is responsible for TCE in groundwater, as documented in the ERM engineering evaluation/cost analysis 1994 report.

- Exposure to upgradient shallow groundwater poses an unacceptable cancer risk, primarily from TCE. Unacceptable noncancer risks also exist in upgradient groundwater due to TCE and 1,2-DCP.

- PCE is only present in on-Base and downgradient shallow wells. Levels of PCE have been observed to decrease over time near Site 5-BCP and at downgradient location MWBP-05. Concentrations of PCE are relatively unchanged at well MWBP-06A, which is crossgradient from Site 5-BCP. The distribution pattern of PCE at the water table suggests that the majority of contaminant mass has migrated off Base.

- PCE is the only significant contaminant originating from past Base activities. Associated risks from exposure to PCE within Base property, however, are within acceptable risk ranges.

10.2.3 Deep Groundwater

The deep aquifer investigation program achieved the established objectives:

- Detailed geologic and hydrogeologic information to a depth of 250 feet bgs was obtained from the exploratory boring program. The hydrogeologic setting is interpreted to consist of a series of connected aquifers with varying degrees of communication. The fact that TCE contamination was detected to depths of 250 feet bgs indicates that aquitards are discontinuous.

- Characterization of the vertical extent of contamination associated with past Base activities was accomplished. PCE was determined to originate from an on-Base source area. Groundwater impacted with PCE extends to a depth no greater than 130 feet bgs. PCE is also not present below the water table at the source area, implying that any PCE entering the aquifer at Site 5-BCP has since migrated away from the source area.

- As a result of the investigation screening program, a deep monitoring well network was installed into units identified as the lower A1 and A2 aquifers. These wells monitor groundwater quality within the deeper portions of the PCE plume and portions below the PCE plume.

- TCE was detected in each deep monitoring well, demonstrating that TCE enters the Base from an upgradient area and migrates both laterally and vertically through groundwater beneath Base property.

- Through a series of aquifer tests, aquifer parameters for the A1 aquifer were estimated. It was also demonstrated that the upper and lower A1 aquifer zones should be considered one aquifer unit. Responses of the aquifer to pumping showed that the aquifer is semiconfined.

- Low concentrations of PCE in groundwater are present within Base property. Given that the greater mass of contaminants have moved off Base, designing a remedial system to remediate on-Base contamination would only affect the trailing end of the plume.

- Aquifer tests showed that each unit can sustain a reasonable pumping rate that causes a limited radius of influence. If a downgradient extraction system is installed to address only PCE contamination, then installing wells in specific zones may be feasible to remove contaminants from more highly impacted layers. If hydraulic control is a desired effect, then extraction wells should be installed through the entire thickness of the A1 aquifer to maximize the available drawdown and resulting capture zone.

11.0 Recommendations

Based on the conclusions from the various investigations presented in this report, recommendations for further activities are proposed as follows:

- PCE groundwater contamination has not been characterized outside of Base property. The horizontal and vertical extent of the PCE plume should, therefore, be determined downgradient of Base property. This would more efficiently be done in coordination with regional contaminant characterizations associated with TCE.

- On-Base groundwater sampling should be performed as part of the continuing regional groundwater investigation.

- Preparing an FS should be delayed until regional investigations for TCE are completed. Combining the FS and any future remedial actions for both the TCE and PCE groundwater plumes offers the greatest efficiency of resources. Aquifer properties that were determined from aquifer tests (Section 5.3.4) can be used in any initial design of a remedial system that may be proposed or developed in the FS.

12.0 References

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APPENDIX A

FIELD LABORATORY INFORMATION: REMEDIAL INVESTIGATION AT SITE 5; DEEP AQUIFER INVESTIGATION

Appendix A

Site 5 Remedial Investigation
Field Screening Laboratory Information
Fresno Air National Guard Project
October 1992

Equipment

Purge and Trap:	Tekmar LSC 2000 with fritted glass sparging vessel. - 5.0 min. purge with UHP helium - 1.0 min. desorb at 180° - 5.0 min. bake at 190°
Gas Chromatograph:	Hewlett Package 5890 Series II DB-624 capillary column Carrier gas: UHP helium at approximately 17.3 mL/min Temperature program: Initial: 40° Hold: 5.0 min. Ramp: 10°/min. Final Temp: 150° Final Time: 1 min
Detector:	O.I. Analytical 4420 Electrolytic Conductivity Detector Reaction gas: UHP hydrogen Electrolyte solution: n-propanol Reaction temperature: 850°C
Data System:	Compaq Deskpro 386 Software: SRI PeakSimple III
Calibration:	A three-point calibration was performed daily for the target compounds. The low-level standard consisted of 100 µg/kg of each compound except 1,2-DCA and 1,1-DCA, which were 80 µg/kg and 60 µg/kg, respectively. The mid-level was 250 µg/kg (1,2-DCA: 200 µg/kg; 1,1-DCA 150 µg/kg). The high level standard was 500 µg/kg (1,2-DCA at 400 µg/kg, 1,1-DCA at 300 µg/kg. Calibrations were performed in accordance with project SAP.
Extractions:	Samples were extracted as follows: a 10 g±0.1 aliquot of soil was vortex-mixed (Scientific Industries Vortex Genie 2) with 10.0 mL purge and trap grade methanol for 2.0 minutes at high speed.

A 0.5 mL fraction of the extract was introduced into a syringe containing 4.5 mL HPLC water. This mixture was introduced into a Tekmar glass-fritted sparging vessel and purged for 5.0 minutes with UHP (Grade 5) helium.

QA/QC Routine:

The following QA/QC samples were run in accordance with project SAP:

- HPLC Blank (water)
- Method blank
- MS/MSD
- End-of-day midpoint check standard.

Laboratory Record Keeping:

All samples were logged in upon receipt in a standard FAS format sample log book.

Each gas chromatograph run was logged into a notebook including run #, sample I.D., lab file I.D., sample volume, matrix, and comments.

A daily notebook was compiled including comments, problems, and observations made during the course of the work day.

Sample results were reported to project geologist on a "field screening laboratory" report sheet created for the Fresno Air National Guard project.

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SB5-Ø1

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-01-6.5'	10.2.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-11.5'	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-16.5'	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-21.5'	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-26.5'	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-31.5	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-36.0	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-41.0	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-~~46~~500'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-55.0'	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-60.0'	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-65.0'	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-71.5'	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-76.5'	10.3.92	<50	<50	<50	<50	<50	<50	<50
SB5-01-81.5'	10.3.92	<50	<50	<50	<50	<50	<50	<50
	/							

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SB5-02

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5.02.85.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5.02.80.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5.02.75.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5.02.70.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5-02.65.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5.02.60.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5-02.55.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5.02.50.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5-02.41.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5-02-25.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5-02.20.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5.02.15.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5.02.10.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5.02.5.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5.02.4.5'	10.1.92	<50	<50	<50	<50	<50	<50	<50

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SB5-Ø3

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-03-5.0'	9.29.92	<98	<50	<50	<50	<50	<50	<50
SB5.03.10.0'	9.29.92	<95	<50	<50	<50	<50	254	329
SB5.03.15.0'	9.29.92	<107	<50	<50	<50	<50	<50	<50
SB5.03.20.0'	9.29.92	<98	<50	<50	<50	<50	56	115
SB5.03.25.0'	9.29.92	<96	<50	<50	<50	<50	<50	<50
SB5.03.30.0'	9.29.92	<101	<50	<50	<50	<50	<50	<50
SB5.03.35.0'	9.29.92	<70	<50	<50	66	<50	410	640
SB5.03.40.0'	9.29.92	<103	<50	<50	<50	<50	<50	<50
SB5.03.45.0'	9.29.92	<103	<50	<50	<50	<50	<50	<50
SB5.03.50.0'	9.29.92	<98	<50	<50	<50	<50	94	167
SB5.03.55.0'	9.29.92	<98	<50	<50	<50	<50	<50	85
SB5-03.60.0'	9.29.92	<136	<50	<50	<50	<50	<50	73
SB5.03.65.0'	9.29.92	<112	111	<50	<50	<50	285	270

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SB5-Ø4

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-04-5.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5-04-10.0'	10.1.92	<50	<50	<50	<50	<50	<50	<50
SB5-04-15.0'	10.2.92	<50	<50	<50	<50	<50	<50	<50
SB5-04-20.0'	10.2.92	<50	<50	<50	<50	<50	<50	51
SB5-04-25.0'	10.2.92	<50	<50	<50	<50	<50	<50	<50
SB5-04-29.5'	10.2.92	<50	<50	<50	<50	<50	61	63
SB5-04-35.0'	10.2.92	<50	<50	<50	<50	<50	<50	<50
SB5-04-40.0'	10.2.92	<50	<50	<50	<50	<50	<50	<50
SB5-04-45.0'	10.2.92	<50	<50	<50	<50	<50	<50	<50
SB5-04-50.0'	10.2.92	<50	<50	<50	<50	<50	<50	<50
SB5-04-55.0'	10.2.92	<50	<50	<50	<50	<50	<50	<50
SB5-04-60.0'	10.2.92	<50	<50	<50	<50	<50	114	100
SB5-04-65.0'	10.2.92	<50	<50	<50	<50	<50	<50	<50

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SB5-Ø5

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-05-4.5/5.0'	9-25-92	<80	<50	<68	<50	<50	<50	<50
SB5-05-9.5/10.0'	9-25-92	<77	<50	<58	<50	<50	<50	<50
SB5-05-14.5/15.0'	9-25-92	<71	<50	<54	<50	<50	<50	<50
SB5-05-19.0/19.5'	9-25-92	<68	<50	<52	<50	<50	<50	<50
SB5-05-24.5/25.0'	9-25-92	<78	<50	<53	<50	<50	<50	<50
SB5-05-29.5/30.0'	9-25-92	<69	<50	<51	<50	<50	51	138
SB5-05-34.5/35.0'	9-25-92	<77	<53	<50	<50	<50	<50	<50
SB5-05-39.5/40.0'	9-28-92	<77	<50	<50	<50	<50	122	219
SB5-05-44.5/45.0'	9-28-92	<77	<50	<50	<50	<50	<50	<50
SB5-05-49.5/50.0'	9-28-92	<66	<50	<50	<50	<50	<50	<50
SB5-05-54.5/55.0'	9-28-92	<73	<50	<50	<50	<50	<50	<50
SB5-05-59.5/60.0'	9-28-92	<68	<50	<50	<50	<50	<50	<50
SB5-05-64.5/65.0'	9-28-92	<72	<50	<50	<50	<50	<50	<50
~~SB5-06-5.0'~~ Jm	~~9-28-92~~ Jm							

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SB5-Ø6

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-06-5.0'	9-28-92	<81	<50	<50	<50	<50	<50	<50
SB5-06-10.0'	9-28-92	290	<50	<50	<50	<50	<50	<50
SB5-06-15.0'	9-28-92	<73	<50	<50	<50	<50	<50	<50
SB5-06-20.0'	9-28-92	<71	<50	<50	<50	<50	<50	<50
SB5-06-25.0'	9-28-92	<67	<50	<50	<50	<50	216	357
SB5-06-30.0'	9-28-92	<63	<50	<50	<50	<50	156	297
SB5-06-35.0'	9-28-92	<83	<50	<50	<50	<50	<50	<50
SB5-06-40.0'	9-29-92	<105	<50	<50	<50	<50	<50	<50
SB5-06-45.0'	9-29-92	<115	<50	<50	<50	<50	<50	<50
SB5-06-50.0'	9-29-92	<105	<50	<50	<50	<50	<50	<50
SB5-06-55.0'	9-29-92	<104	<50	<50	<50	<50	<50	58
SB5-06-60.0'	9-29-92	<101	<50	<50	<50	<50	<50	92
SB5-06-65.0'	9-29-92	<86	<50	<50	<50	<50	206	244
JM ~~SB5-03-5.0'~~	~~9-29-92~~	~~<98~~	~~<50~~	~~<50~~	~~<50~~	~~<50~~	~~<50~~	~~<50~~

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SB5-Ø7

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-07-10.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-15.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-20.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-~~20.0'~~ 25.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-30.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-34.5'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-40.0'	9.30.92	<50	<50	<50	<50	<50	<50	52
SB5-07-45.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-50.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-55.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-60.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50
SB5-07-65.0'	9.30.92	<50	<50	<50	<50	<50	<50	<50

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SB5-Ø8

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-08.6.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.11.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.16.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.21.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5.08.26.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5.08.31.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.36.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.41.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5.08.46.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.56.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5.08.61.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.66.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.71.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.76.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.81.5'	10.6.92	<50	<50	<50	<50	<50	<50	<50
SB5-08.86.5	10.6.92	<50	<50	<50	<50	<50	<50	<50

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SB5-09

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-09.6.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5-09.11.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5.09.16.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5.09.21.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5-09.26.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5-09.31.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5-09.36.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5-09.46.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5-09.51.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5.09.56.5'	10.7.92	<50	<50	<50	<50	<50	<50	<50
SB5-09.61.5'	10.8.92	<50	<50	<50	<50	<50	<50	<50
SB5.09.66.5'	10.8.92	<50	<50	<50	<50	<50	<50	<50
SB5.09.71.5'	10.8.92	<50	<50	<50	<50	<50	<50	<50
SB5-09-76.5'	10.8.92	<50	<50	<50	<50	<50	<50	<50
SB5-09.81.5'	10.8.92	<50	<50	<50	<50	<50	<50	<50
SB5-09.86.5'	10.8.92	<50	<50	<50	<50	<50	<50	<50

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SB5-10

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-10-6.5'	10.9.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-11.5'	10.9.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-16.5'	10.9.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-21.5'	10.9.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-26.5'	10.9.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-31.5'	10.9.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-41.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-46.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-51.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-56.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-61.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-66.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-71.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-76.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-10-86.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50

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SB5-11

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-11.6.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.11.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.16.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.21.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.26.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.31.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.36.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.41.5'	10.13.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.46.5'	10.14.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.51.5'	10.14.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.56.5'	10.14.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.61.5'	10.14.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.66.5'	10.14.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.71.5'	10.14.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.76.5'	10.14.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.81.5'	10.14.92	<50	<50	<50	<50	<50	<50	<50
SB5-11.66.5'	10.14.92	<50	<50	<50	<50	<50	<50	<50

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SB5-12

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5·12·11.5'	10·14·92	<50	<50	<50	<50	<50	<50	<50
SB5·12·21.5'	10·14·92	<50	<50	<50	<50	<50	<50	<50
SB5-12·31.5'	10·14·92	<50	<50	<50	<50	<50	<50	<50
SB5-12·41.5'	10·14·92	<50	<50	<50	<50	<50	<50	<50
SB5-12·51.5'	10·14·92	<50	<50	<50	<50	<50	<50	<50
SB5-12·61.5'	10·14·92	<50	<50	<50	<50	<50	<50	<50
SB5·12·71.5'	10·15·92	<50	<50	<50	<50	<50	<50	<50
SB5·12·76.5	10·15·92	<50	<50	<50	<50	<50	<50	<50
SB5·12·86.0'	10·15·92	<50	<50	<50	<50	<50	<50	<50

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ADDITIONAL SAMPLES

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
SB5-03-13.5'	10-8-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-63.0'	10-8-92	<50	<50	<50	<50	<50	<50	<50
SB5-04-23.0'	10-8-92	<50	<50	<50	<50	<50	<50	<50
SB5-05-42.5/43.0	10-8-92	<50	<50	<50	<50	<50	<50	<50
SB5-06-18.0'	10-8-92	<50	<50	<50	<50	<50	<50	<50

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DRUM SAMPLES

Results (ug/Kg)								
Sample Number	Date of Analysis	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
MWBP.09.70/95'	10.2.92	<50	<50	<50	<50	<50	<50	<50
MWBP.10.0/35'	10.2.92	<50	<50	<50	<50	<50	<50	<50
MWBP.10.35/45'	10.2.92	<50	<50	<50	<50	<50	<50	<50
MWBP-11.35/60'	10.2.92	<50	<50	<50	<50	<50	<50	<50
MWBP.11.60/90'	10.2.92	<50	<50	<50	<50	<50	<50	<50
MWBP.11.0/35'	10.7.92	<50	<50	<50	<50	<50	<50	<50
MWBP.09.40/70'	10.7.92	<50	<50	<50	<50	<50	<50	<50
MWBP.12.20/30'	10.14.92	<50	<50	<50	<50	<50	<50	<50
MWBP.12.50/55'	10.14.92	<50	<50	<50	<50	<50	<50	<50
MWBP.12.85/90'	10.14.92	<50	<50	<50	<50	<50	<50	<50

Deep Aquifer Investigation
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Equipment/Set-Up

Equipment:

Purge and Trap: Tekmar LSC 2000 with fritted 5 mL glass sparging vessel and #3 trap.

Gas chromatograph: Hewlett Packard 5890 Series II, I.D. #: 506132

Detector: O.I. Corporation 4420 Electrolytic Conductivity Detector

Integrator: Hewlette Packard 3396 Series II I.D. #: 506702

Set Up:

Purge and Trap:

- 5.0 min. purge with high purity nitrogen at 20 psi
- 6.0 min. dry purge
- 2.0 min. desorb
- 8:00 min. bake

Gas Chromatograph:

Carrier gas (high purity hydrogen) flow set at 11.8 mL/min
Temperature program: Initial: 40°C hold for 5:00 min.
Ramp 10 deg./min. til 195°C
hold for 1:00 min.

Detector:

Electrolytic solution n-propanol lot # 333152
Reaction temperature: 850°C
Attenuation set at 2
Mode "H"

Deep Aquifer Investigation
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Laboratory Record Keeping

1. All samples were logged in upon receipt into a standard FAS sample receipt log.All QC information was also recorded in this log.

2. All soils were extracted within 2 hours and were recorded in a standard FAS extraction log book. This included sample weight, solvent volume and time performed.

3. Each gas chromatograph run was logged into a notebook. The information included run number, sample number, sampled amount, matrix, and comments.

4. Sample results were reported to the project geologist on a field screening report sheet on a daily basis.

5. All raw and field generated data will be held on file at Martinez FAS West.

Deep Aquifer Investigation
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Calibration and Extraction Procedure

Calibration:

A three point calibration[1] was performed at the beginning of each day. The standards were prepared as follows:

50 µg/L std.: 2.5 µL of 20 µg/mL std. was introduced into a solution of 0.5 mL purge and trap grade methanol and 4.5 mL of HPLC water.

100 µg/L std.: 5.0 µl of 20 µg/mL std. was introduced into a solution of 0.5 mL purge and trap grade methanol and 4.5 mL of HPLC water.

200 µg/L std.: 10 µl of 20 µg/mL std. was introduced into a solution of 0.5 mL purge and trap grade methanol and 4.5 mL of HPLC water.

The calibration was accepted or rejected based on the criteria of all target compounds possessing a linear coefficient of 0.990 or better.

After the calibration was complete it was followed by a method blank consisting of 0.5 mL purge and trap grade methanol and 4.5 mL of HPLC water. The method blank was then accepted only if all target compounds were below reporting limits.

At the end of each day a mid-point check standard (100 µg/l) was analyzed in order to verify calibration.

Extraction Procedure:

Soil samples were extracted by weighing out 20.00 g of sample into a 40 mL VOA bottle which held 10 mL of purge and trap grade methanol. The VOA bottle was hand shaken for two minutes and allowed to settle. Then 0.5 mL of the

[1]The calibration is based on soil analysis. The calibration range for waters was computed by dividing the result by a factor of five. Therefore, the standards are 10 µg/l, 20 µg/l, and 40 µg/L.

extract was drawn from the VOA bottle and added to 4.5 mL of HPLC water and injected into the purge vessel. Water samples were not extracted. Five mL of water samples were directly injected into the purge vessel.

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SOIL BORING # : EXB-01

Soil sample results. Reported in Ug/Kg

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
EXB-01-46.5	10/05/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-01-70	10/06/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-01-148	10/07/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-01-177	10/07/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-01-203	10/08/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-01-243	10/08/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50

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SOIL BORING # : EXB-01

Water sample results. Reported in Ug/L

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
EXB-01-122 GW	10/06/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-01-142 GW	10/06/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-01-215 GW	10/08/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-01-248 GW	10/08/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-01-142 RF[1]	10/06/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-01-190 RF[1]	10/07/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5

[1] RF = Return flow sample.

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SOIL BORING # : EXB-02

Soil sample results. Reported in Ug/Kg

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1 ,2 DCE	1,2 DCA	TCE	PCE
EXB-02-40	10/12/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-02-85	10/12/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-02-145	10/13/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-02-180	10/13/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-02-238	10/14/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50

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SOIL BORING # : EXB-02

Water sample results. Reported in Ug/L

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
EXB-02-101 GW	10/12/93	< 5	< 5	< 5	30	< 5	200 D	< 5
EXB-02-133 GW	10/12/93	< 5	< 5	< 5	30	< 5	150 D	< 5
EXB-02-154 GW	10/12/93	< 5	< 5	< 5	< 5	< 5	30	< 5
EXB-02-220 GW	10/13/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-02-248 GW	10/14/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-02-248 GW FD	10/14/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5

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SOIL BORING # : EXB-03

Soil sample results. Reported in Ug/Kg

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1 ,2 DCE	1,2 DCA	TCE	PCE
EXB-03-34	10/15/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-03-92	10/15/93	< 50	93	< 50	< 50	< 50	< 50	< 50
EXB-03-123	10/15/93	<50	95	56	< 50	< 50	< 50	< 50
EXB-03-178	10/16/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-03-208	10/17/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-03-254	10/17/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50

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SOIL BORING # : EXB-03

Water sample results. Reported in Ug/L

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
EXB-03-88 GW	10/15/93	< 5	10	< 5	< 5	< 5	9	26
EXB-03-101 GW	10/15/93	< 5	< 5	< 5	< 5	< 5	25	10
EXB-03-134 GW	10/15/93	12	< 5	6	29	< 5	320 D	< 5
EXB-03-152 GW	10/16/93	< 5	< 5	< 5	< 5	< 5	11	< 5
EXB-03-171 GW	10/16/93	< 5	< 5	< 5	< 5	< 5	120 D	< 5
EXB-03-207 GW	10/16/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-03-247 GW	10/17/93	< 5	< 5	< 5	< 5	< 5	16	< 5

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SOIL BORING # : EXB-04

Soil sample results. Reported in Ug/Kg

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1 ,2 DCE	1,2 DCA	TCE	PCE
EXB-04-45	10/26/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-04-95	10/26/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-04-151	10/27/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-04-188	10/28/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-04-241	10/28/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50

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SOIL BORING # : EXB-04

Water sample results. Reported in Ug/L

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
EXB-04-106 GW	10/27/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-04-142 GW	10/27/93	8	6	< 5	25	< 5	440 D	< 5
EXB-04-162 GW	10/27/93	<5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-04-186 GW	10/27/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-04-208 GW	10/28/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5

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SOIL BORING # : EXB-05

Soil sample results. Reported in Ug/Kg

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1 ,2 DCE	1,2 DCA	TCE	PCE
EXB-05-15	10/18/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-05-89	10/19/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-05-148	10/20/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-05-188	10/20/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50
EXB-04-244	10/20/93	< 50	< 50	< 50	< 50	< 50	< 50	< 50

I.T. CORPORATION
FIELD SCREENING LABORATORY
FRESNO AIR NATIONAL GUARD
PROJECT 409724

SOIL BORING # : EXB-05

Water sample results. Reported in Ug/L

SAMPLE NUMBER	DATE OF ANALYSIS	1,1 DCE	trans 1,2 DCE	1,1 DCA	cis 1,2 DCE	1,2 DCA	TCE	PCE
EXB-05-108 GW	10/19/93	< 5	< 5	< 5	< 5	< 5	290 D	106
EXB-05-143 GW	10/20/93	< 5	< 5	< 5	< 5	< 5	54	< 5
EXB-05-162 GW	10/20/93	< 5	< 5	< 5	< 5	< 5	29	< 5
EXB-05-171 GW	10/20/93	< 5	< 5	< 5	< 5	< 5	59	< 5
EXB-05-202 GW	10/20/93	< 5	< 5	< 5	< 5	< 5	< 5	< 5
EXB-05-223 GW	10/21/93	< 5	< 5	< 5	10	< 5	180	< 5
EXB-05-251 GW	10/21/93	< 5	< 5	< 5	< 5	< 5	14	< 5

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FIELD SCREENING LABORATORY
FRESNO AIR NATIONAL GUARD
PROJECT # 409724
QA/QC

SAMPLE INFORMATION				% R						
MS/MSD SAMPLE	DATE	MATRIX	SPIKE AMOUNT	1,1 DCE	trans 1,2 DCE	1,1 DCA	CIS 1,2 DCE	1,2 DCA	TCE	PCE
EXB-02-238	10/14/93	SOIL	100 UL OF 20Ug/ml	86	76	128	105	99	114	115
EXB-02-238	10/14/93	SOIL	100 UL OF 20Ug/ml	114	58	136	161	86	105	101
EXB-04-92	10/27/93	SOIL	100 UL OF 20Ug/ml	111	116	112	114	102	106	108
EXB-04-92	10/27/93	SOIL	100 UL OF 20Ug/ml	110	150	141	142	68	110	111
EXB-04-162	10/27/93	WATER	5 UL OF 20Ug/ml	127	115	106	115	66	90	97
EXB-04-162	10/27/93	WATER	5 UL OF 20Ug/ml	109	89	50	74	50	82	86

All Q/C requirements for MS/MSD,s were met (One set per twenty samples). All percent recoveries were within the percent recovery limits (50%-100% recovery).

<u>MS/MSD's were prepared as follows:</u>

Soils: 20.00g of soil added to 10 ml of purge and trap grade methanol then spiked with 100 ul of 20 ug/ml standard. This mixture was then shaken for two minutes. 0.5 ml of the extract was then introduced into 4.5 ml of HPLC water and immediately injected into the purge vessel of the purge and trap. Expected result of 100 ppm.

Waters: 5 ul of 20 Ug/ml standard is added to 5 ml of sample the immediately injected into the purge vessel of the purge and trap. Expected value of 20 Ug/l.

APPENDIX B

MONITORING WELL AND PIEZOMETER INFORMATION

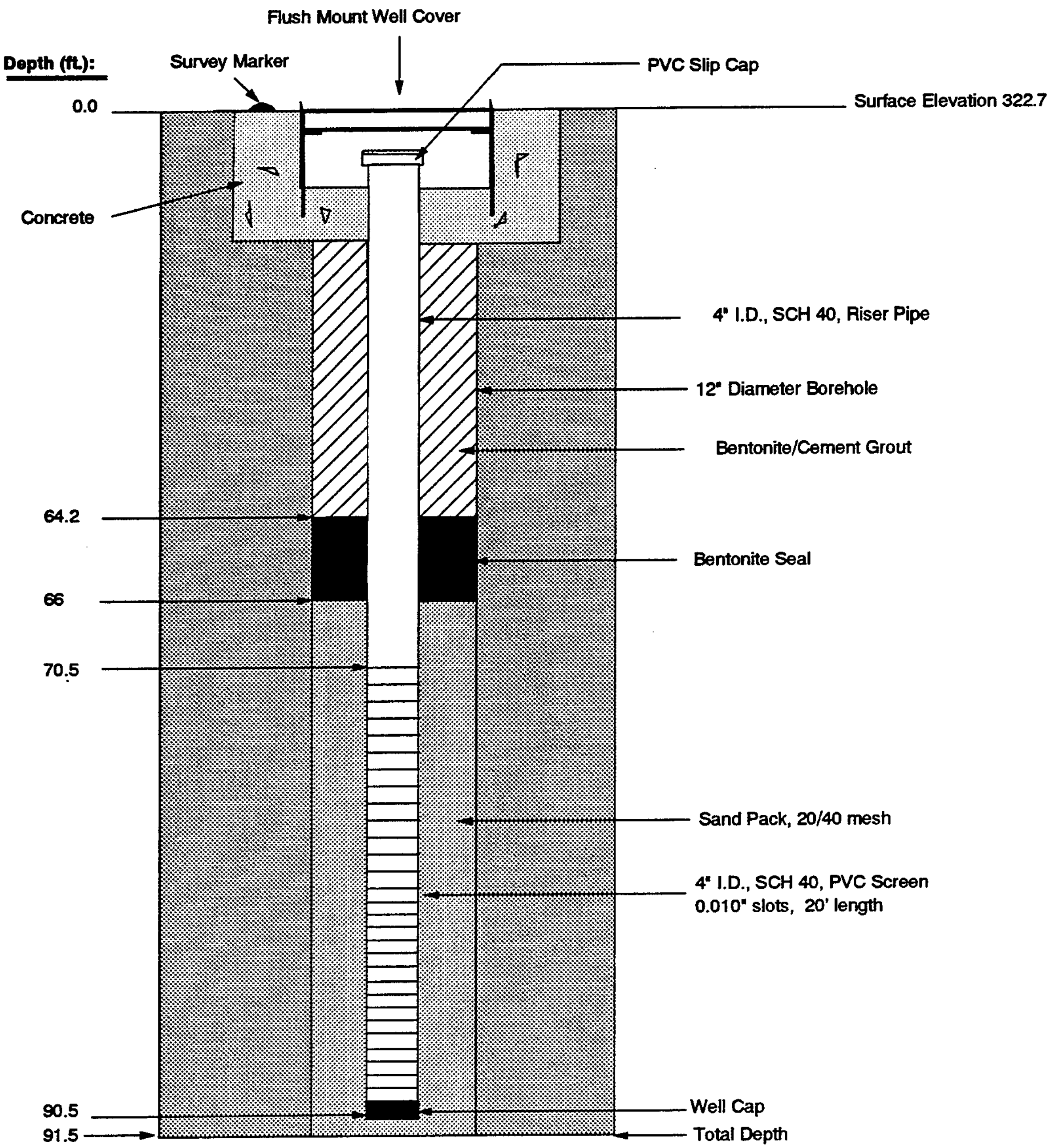
Final Well Construction Specifications
California Air National Guard - Fresno, California

Well ID	Installation Date	Ground Surface Elevation[a]	Top of Casing Elevation[a]	Screened Interval[b]	Filter Pack Interval[b]	Top of Bentonite[b]	Well Diameter (inches)	Northing (y)	Easting (x)
MW1-01	19 Oct. 90	328.9	328.78	92.6-72.6	95.0-70.0	68.5	2.0	2162987.0	6355548.7
MW1-02	23 Oct. 90	327.9	327.68	92.0-72.0	94.0-68.0	66.0	2.0	2162894.6	6355276.4
MW1-03	23 Oct. 90	328.1	327.93	93.0-73.0	93.5-70.0	68.0	2.0	2162864.3	6355324.3
MW2-01	20 Sep. 90	322.2	322.02	93.0-73.0	93.0-69.5	66.0	2.0	2162879.5	6352428.1
MW2-02	2 Oct. 90	321.3	320.96	92.0-72.0	93.0-69.0	66.3	2.0	2162663.5	6352146.5
MW2-03	19 Sep. 90	320.9	320.83	91.3-71.3	92.0-69.0	66.5	2.0	2162694.0	6352095.2
MW3-01A	9 Nov. 90	331.6	331.33	92.3-72.3	92.5-69.8	66.3	2.0	2167250.3	6352819.8
MW4-01	4 Oct. 90	327.8	327.61	91.5-71.5	93.5-69.7	67.3	2.0	2162510.2	6355284.5
MW4-02	3 Oct. 90	327.0	327.06	91.0-71.0	93.5-65.8	60.6	2.0	2162466.6	6355134.6
MW5-01	8 Oct. 92	322.7	322.19	90.5-70.5	91.5-66.0	64.2	4.0	2163141.2	6352693.3
MW5-01B	3 Nov. 93	322.5	321.91	118-108	118.5-103.5	98.5	5.0	2163117.8	6352717.8
MW5-01C	2 Nov. 93	323.1	322.61	146-136	146.5-132.0	127	5.0	2163163.6	6352670.5
MW5-02	1 Oct. 92	324.2	323.62	92.5-72.5	92.5-68.0	66.3	4.0	2162907.2	6352559.0
BMW-2	2 Feb. 91	332.9	335.24	91.8-71.8	92.5-69.1	66.9	2.0	2167550.5	6353065.7
MWBP-01	9 Oct. 90	326.9	326.73	91.7-71.7	93.1-69.2	66.9	2.0	2163367.7	6353833.5
MWBP-02	10 Oct. 90	324.2	324.11	89.9-69.9	92.0-66.8	64.3	2.0	2163907.0	6353112.9
MWBP-03	10 Oct. 90	324.1	325.92	92.3-72.3	92.5-69.8	67.5	2.0	2163409.6	6352779.0
MWBP-04	17 Oct. 90	323.5	323.40	91.7-71.7	93.5-69.7	67.0	2.0	2163434.4	6351950.0
MWBP-05	25 Oct. 90	320.3	320.04	93.1-73.1	93.5-69.0	67.0	2.0	2162531.1	6351737.2
MWBP-05B	8 Nov. 93	320.5	319.80	116-106	117-101.5	96.5	5.0	2162545.7	6351838.1
MWBP-05C	7 Nov. 93	320.3	319.57	149.2-139.2	152-135	129	5.0	2162531.7	6351770.9
MWBP-06A	8 Nov. 90	321.4	321.00	93.5-73.5	94.5-71.0	68.2	2.0	2162529.4	6352488.9
MWBP-06B	16 Nov. 93	321.6	320.84	114-104	115-100	95	5.0	2162509.8	6352518.5
MWBP-06C	10 Nov. 93	321.3	320.56	146.5-136.5	148-133	128	5.0	2162557.8	6352449.9
MWBP-07	31 Oct. 90	321.2	320.87	91.0-71.0	95.3-67.0	65.0	2.0	2162524.0	6352987.5
MWBP-08	29 Oct. 90	322.1	321.73	93.0-73.0	95.5-69.5	67.0	2.0	2162509.8	6353333.9
MWBP-09	10 Sep. 92	325.1	324.58	94.0-74.0	94.5-69.0	66.3	4.0	2163693.9	6353411.7
MWBP-09B	5 Nov. 93	324.9	324.36	115.5-105.5	116-101	96.5	5.0	2163675.8	6353436.8
MWBP-09C	4 Nov. 93	324.8	324.29	146.5-136.5	148-132	127.5	5.0	2163714.0	6353382.8
MWBP-10	16 Sep. 92	324.2	323.68	94.5-74.5	95.0-70.1	68.4	4.0	2163421.0	6352331.5
MWBP-11	14 Sep. 92	322.0	321.76	94.5-74.5	95.0-70.4	68.5	4.0	2163041.4	6351748.8
MWBP-12	22 Sep. 92	320.8	320.48	92.5-72.5	93.0-68.5	66.5	4.0	2162553.0	6352214.7
P-1	16 Mar. 95	320.9	320.48	82.5-92.5	93.5-79.5	76.5	1.5	2162565.3	6352206.4
P-2	17 Mar. 95	320.8	320.28	82.5-92.5	93.5-79.3	76.0	1.5	2162588.9	6352248.7
P-3(B)	13 Mar. 95	320.7	320.08	106-116	117.5-102.8	98.1	1.5	2162533.6	6351853.7
P-4(A)	14 Mar. 95	321.5	320.75	83-93	94.0-80.0	78.1	1.5	2162551.9	6351877.4
P-5(B)	15 Mar. 95	321.7	321.37	106-116	117.0-103.0	97.9	1.5	2162595.6	6351923.1

a - Measurements are in feet mean sea level.
b - Measurements are in feet below ground surface.

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



Drilling Started 10/02/92
Well Installed 10/08/92
Developed 10/15/92
Drilling Co. Spectrum Exploration
Notes:

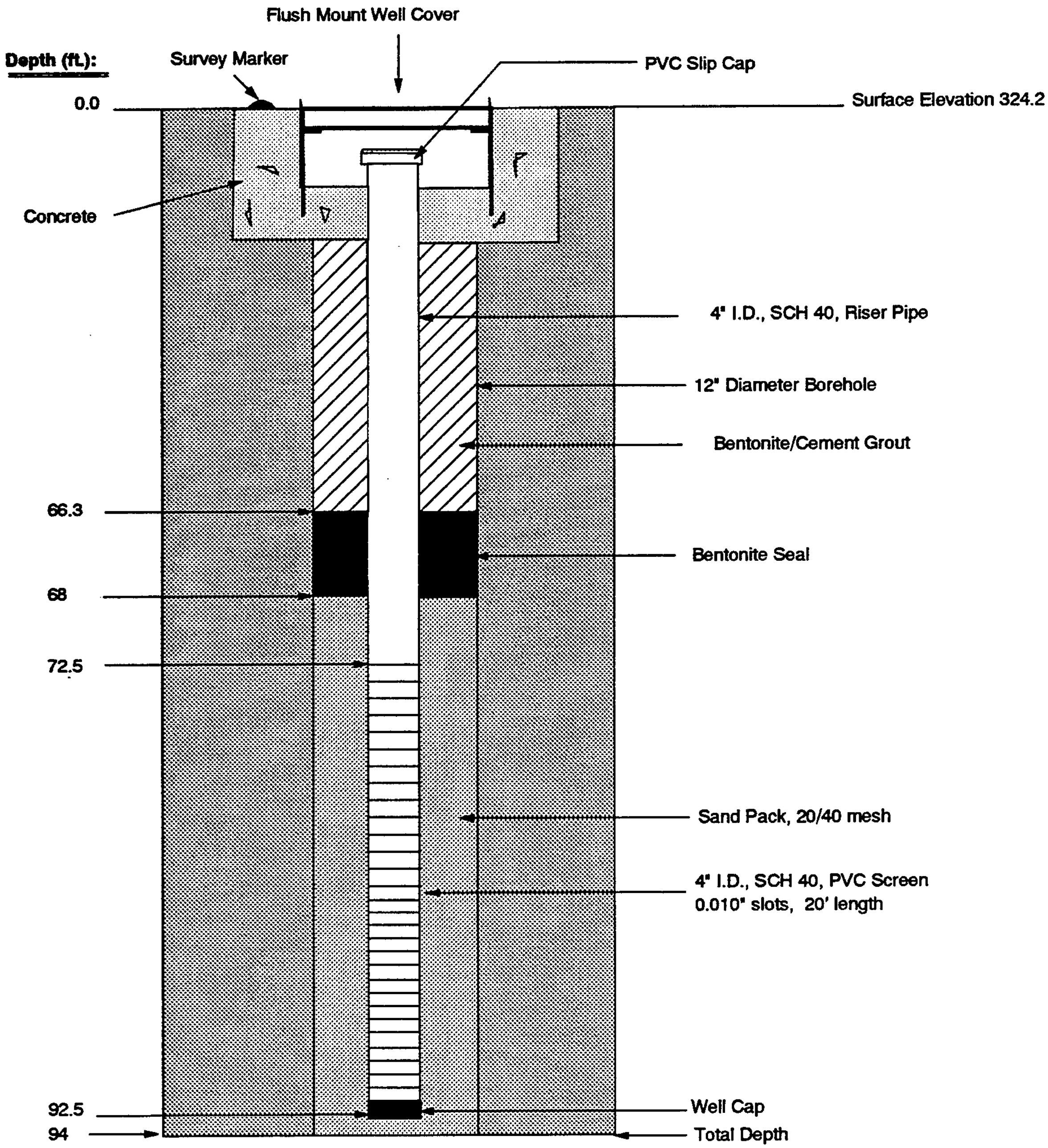
MONITORING WELL CONSTRUCTION DIAGRAM

Well No. MW5-01
Facility Fresno ANG Base
Fresno, California
Job No. 409724

FRESNO\MW5-01\mc\12-22-94

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



Drilling Started 09/29/92

Well Installed 10/01/92

Developed 10/06/92

Drilling Co. Spectrum Exploration

Notes:

MONITORING WELL CONSTRUCTION DIAGRAM

Well No. MW5-02

Facility Fresno ANG Base

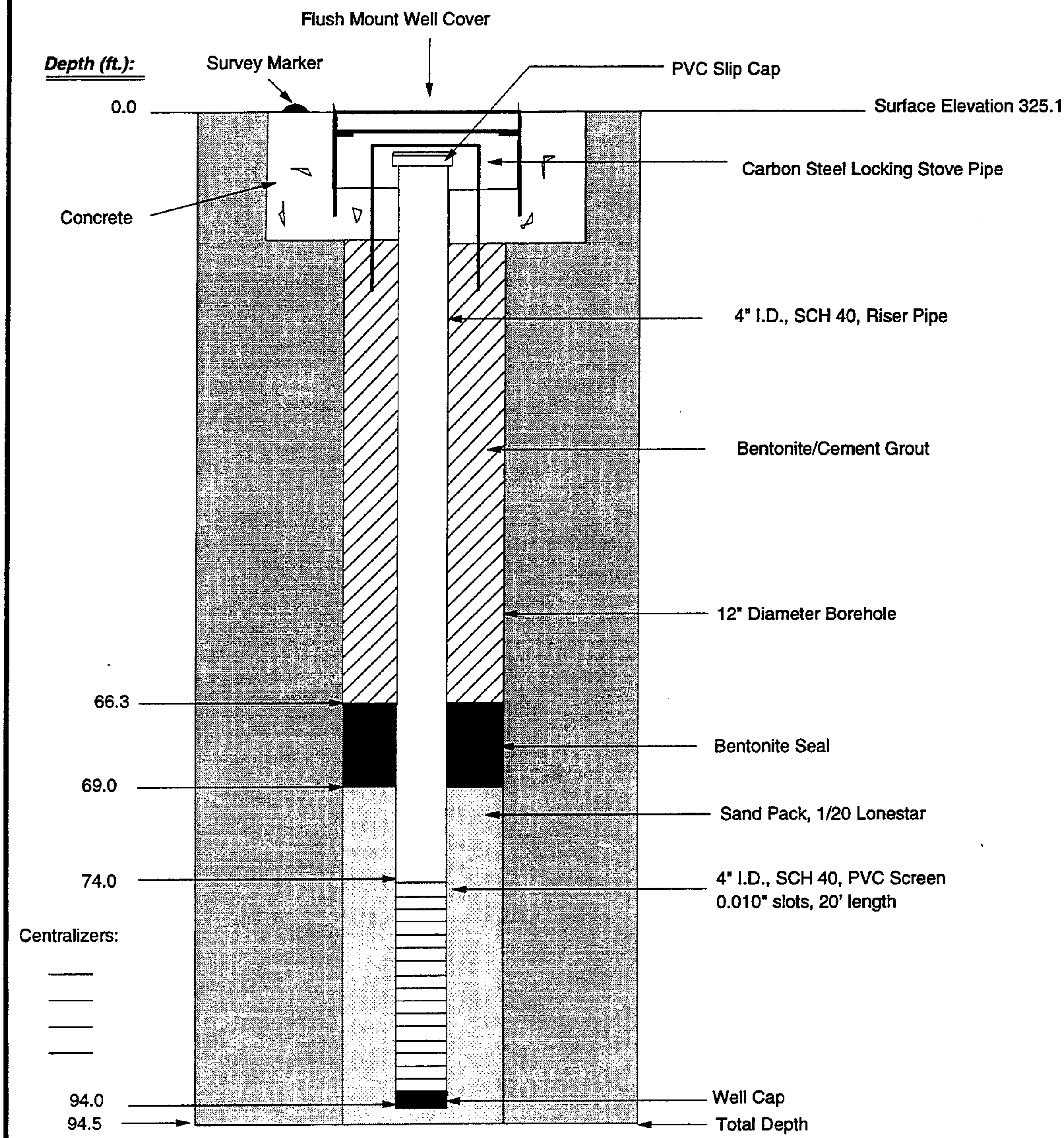
Fresno, California

Job No. 409724

FRESNO\MW5-02\mc\12-22-94

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



MONITORING WELL CONSTRUCTION DIAGRAM

Drilling Starter 9/10/92

Well Installed 9/10/92

Developed 9/18/92

Drilling Co. Spectrum Exploration

Notes:

Well No. MWBP-09

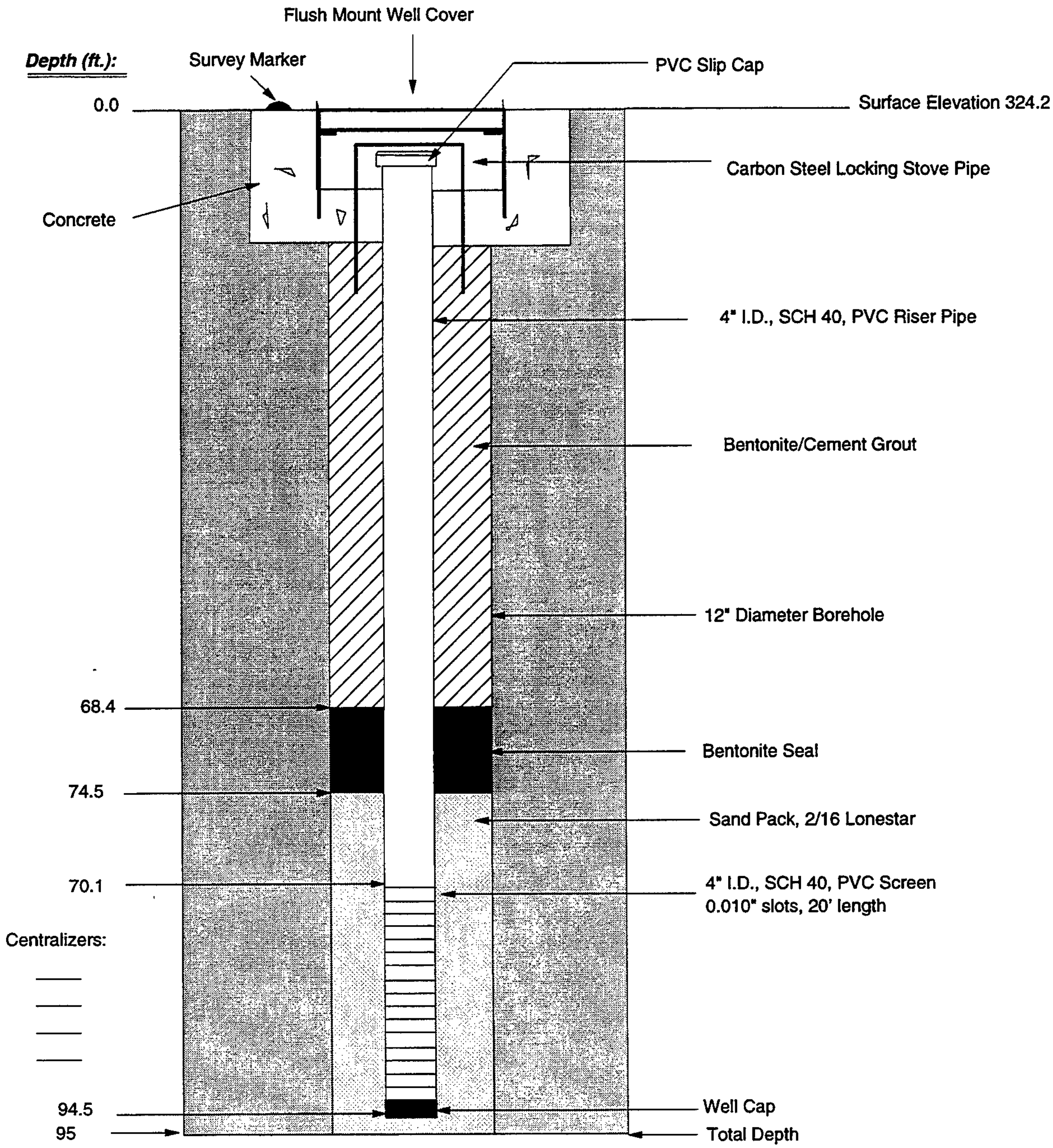
Facility Fresno ANG Base
Fresno, California

Job No. 409724

FRESNO\MWBP-09\mc\10-10-95

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



Drilling Starter 9/16/92

Well Installed 9/16/92

Developed 9/30/92

Drilling Co. Spectrum Exploration

Notes:

MONITORING WELL CONSTRUCTION DIAGRAM

Well No. MWBP-10

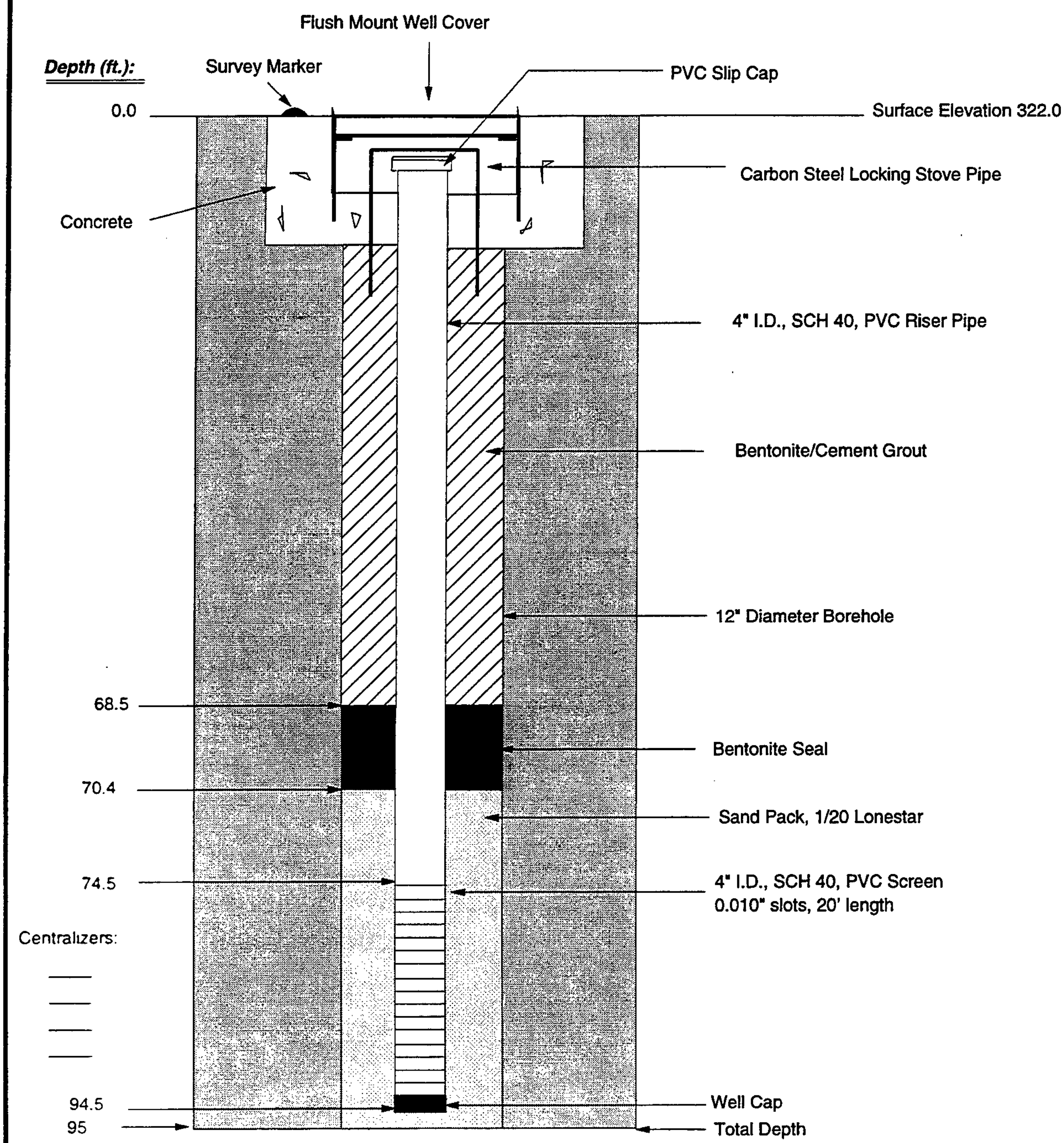
Facility Fresno ANG Base
Fresno, California

Job No. 409724

FRESNO\MWBP-10\mc\10-10-95

INTERNATIONAL
TECHNOLOGY-
CORPORATION

(Not To Scale)



MONITORING WELL CONSTRUCTION DIAGRAM

Drilling Starter 9/14/92

Well Installed 9/14/92

Developed 9/18/92

Drilling Co. Spectrum Exploration

Notes:

Well No. MWBP-11

Facility Fresno ANG Base

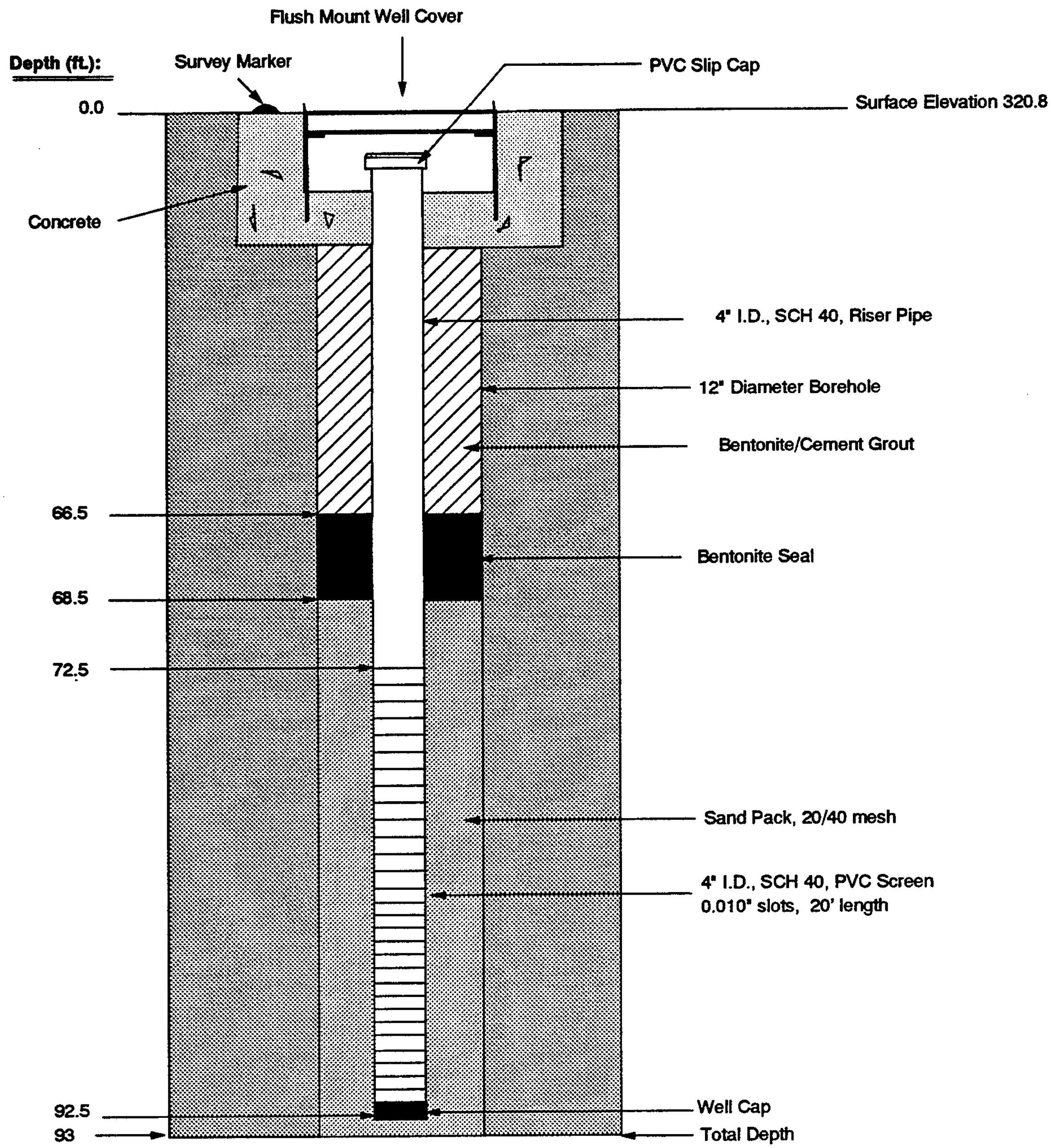
Fresno, California

Job No. 409724

FRESNO\MWBP-11\mc\10-10-95

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



Drilling Started 09/21/92

Well Installed 09/22/92

Developed 09/30/92

Drilling Co. Spectrum Exploration

Notes:

MONITORING WELL CONSTRUCTION DIAGRAM

Well No. MWBP-12

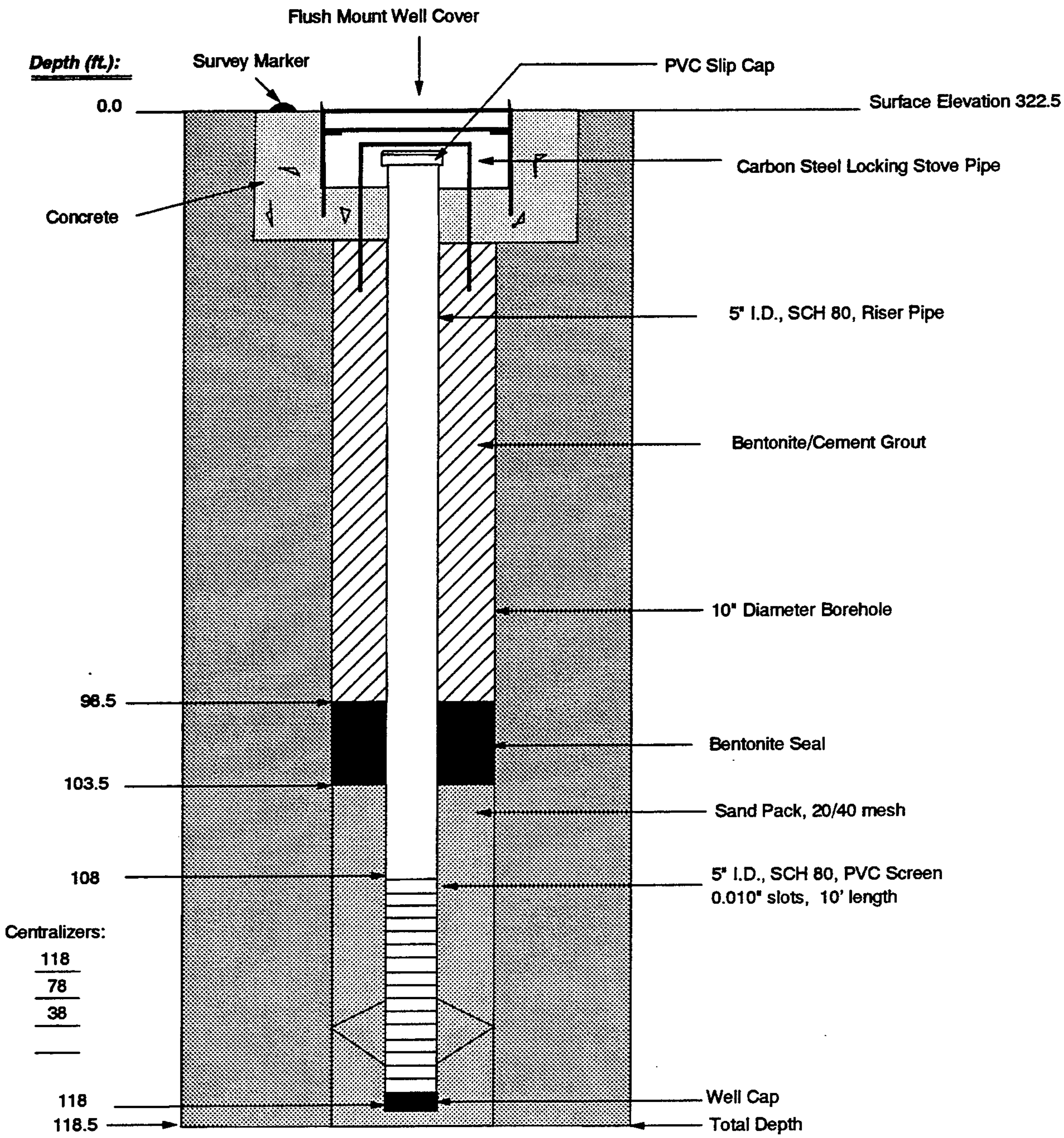
Facility Fresno ANG Base
Fresno, California

Job No. 409724

FRESNO\MWBP-12\mc\12-22-94

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



Drilling Starter 11/2/93

Well Installed 11/3/93

Developed 11/13/93

Drilling Co. Water Development Corp.

Notes:

MONITORING WELL CONSTRUCTION DIAGRAM

Well No. MW5-01B

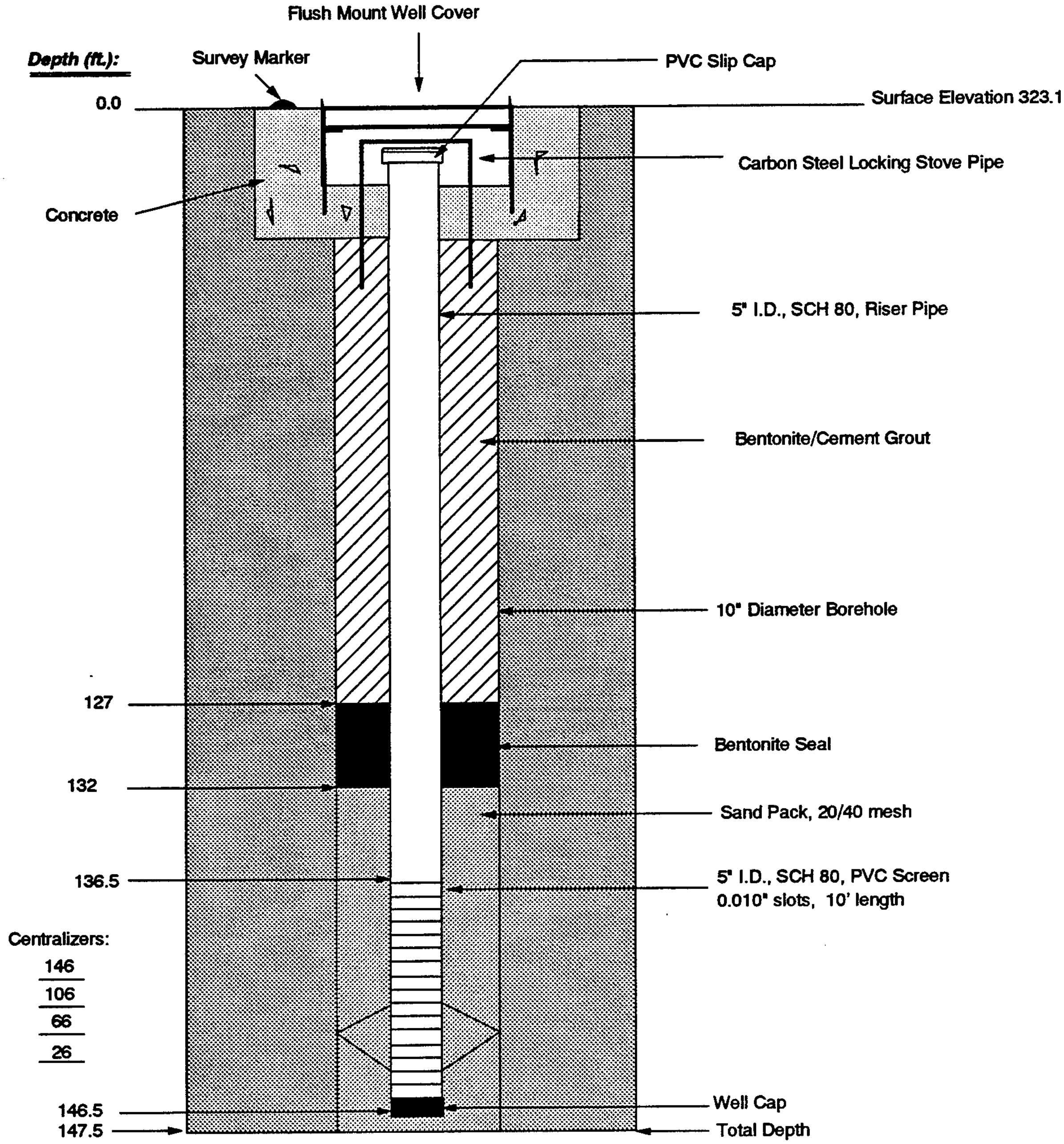
Facility Fresno ANG Base

Fresno, California

Job No. 409724

FRESNO\MW5-01B\mb\10-10-94

(Not To Scale)



Drilling Starter 11/1/93
Well Installed 11/2/93
Developed 11/13/93
Drilling Co. Water Development Corp.
Notes:

MONITORING WELL CONSTRUCTION DIAGRAM

Well No. MW5-01C
Facility Fresno ANG Base
Fresno, California
Job No. 409724

FRESNO\MW5-01C\mb\10-10-94

INTERNATIONAL TECHNOLOGY CORPORATION

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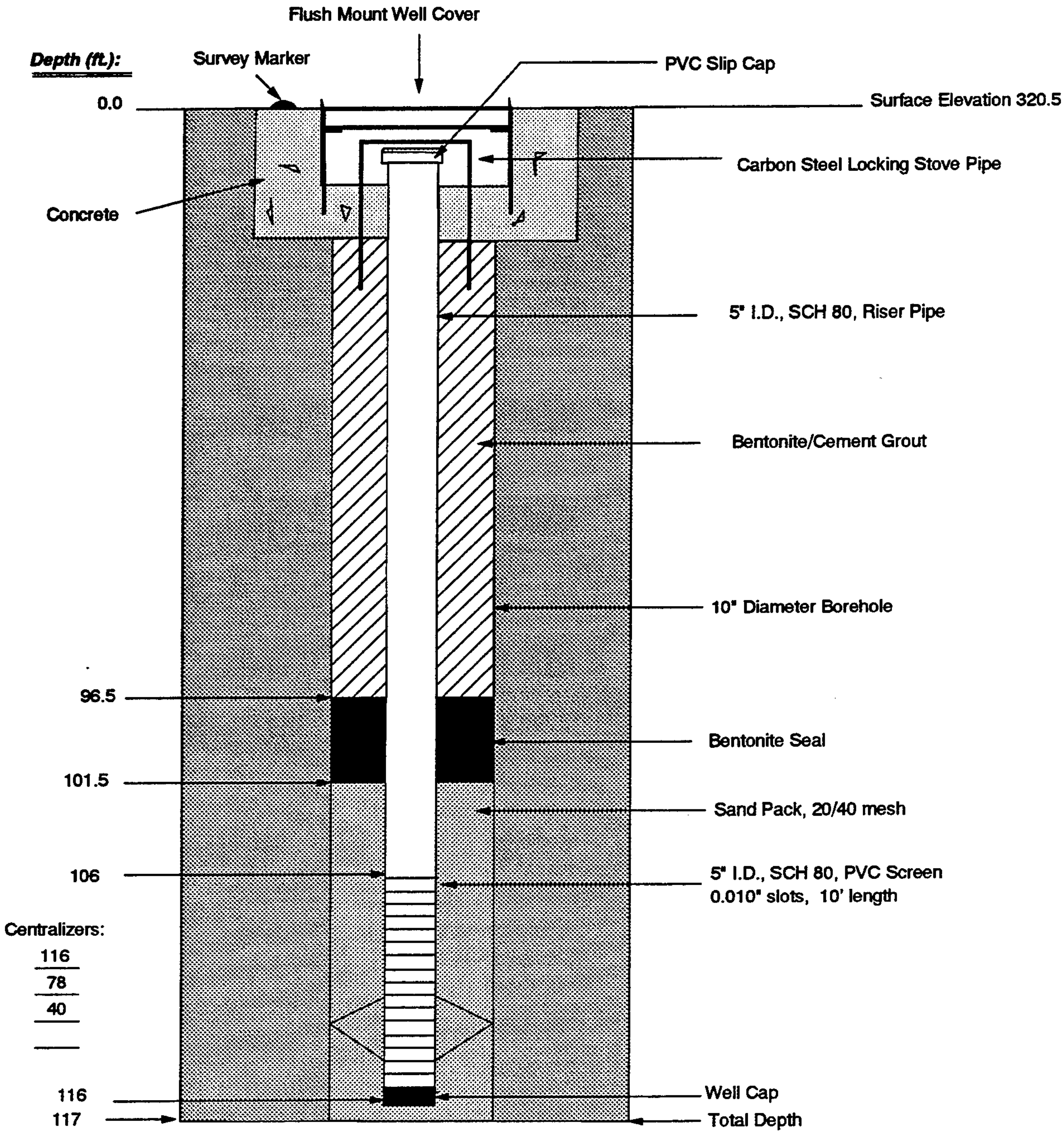


MONITORING WELL CONSTRUCTION DIAGRAM

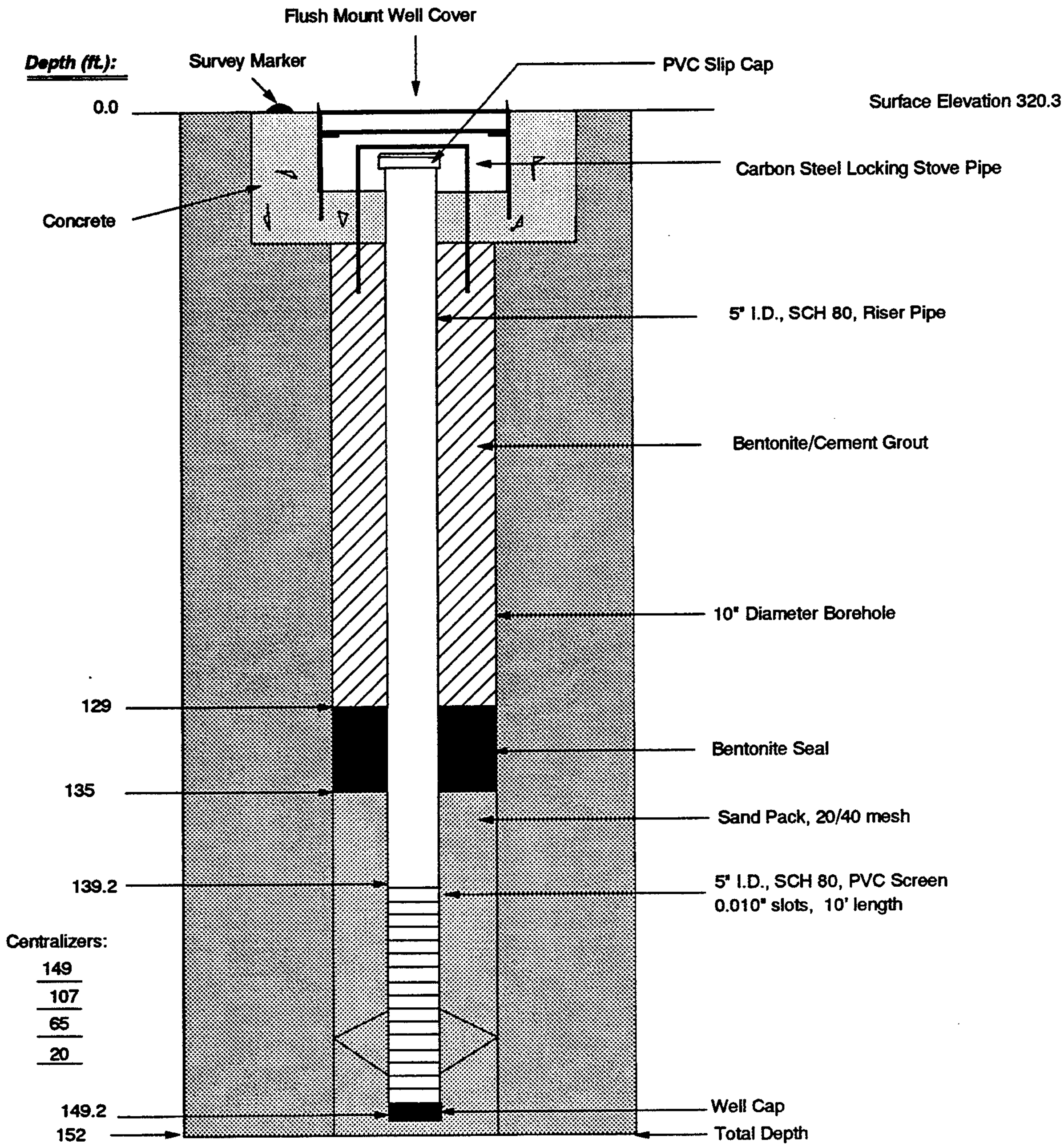
Drilling Starter 11/7/93
Well Installed 11/8/93
Developed 11/21/93
Drilling Co. Water Development Corp.
Notes:

Well No. MWBP-05B
Facility Fresno ANG Base
Fresno, California
Job No. 409724

FRESNO\MWBP-05B\mb\10-10-94

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



MONITORING WELL CONSTRUCTION DIAGRAM

Drilling Starter 11/6/93

Well Installed 11/6,7/93

Developed 11/22/93

Drilling Co. Water Development Corp.

Notes: ______

Well No. MWBP-05C

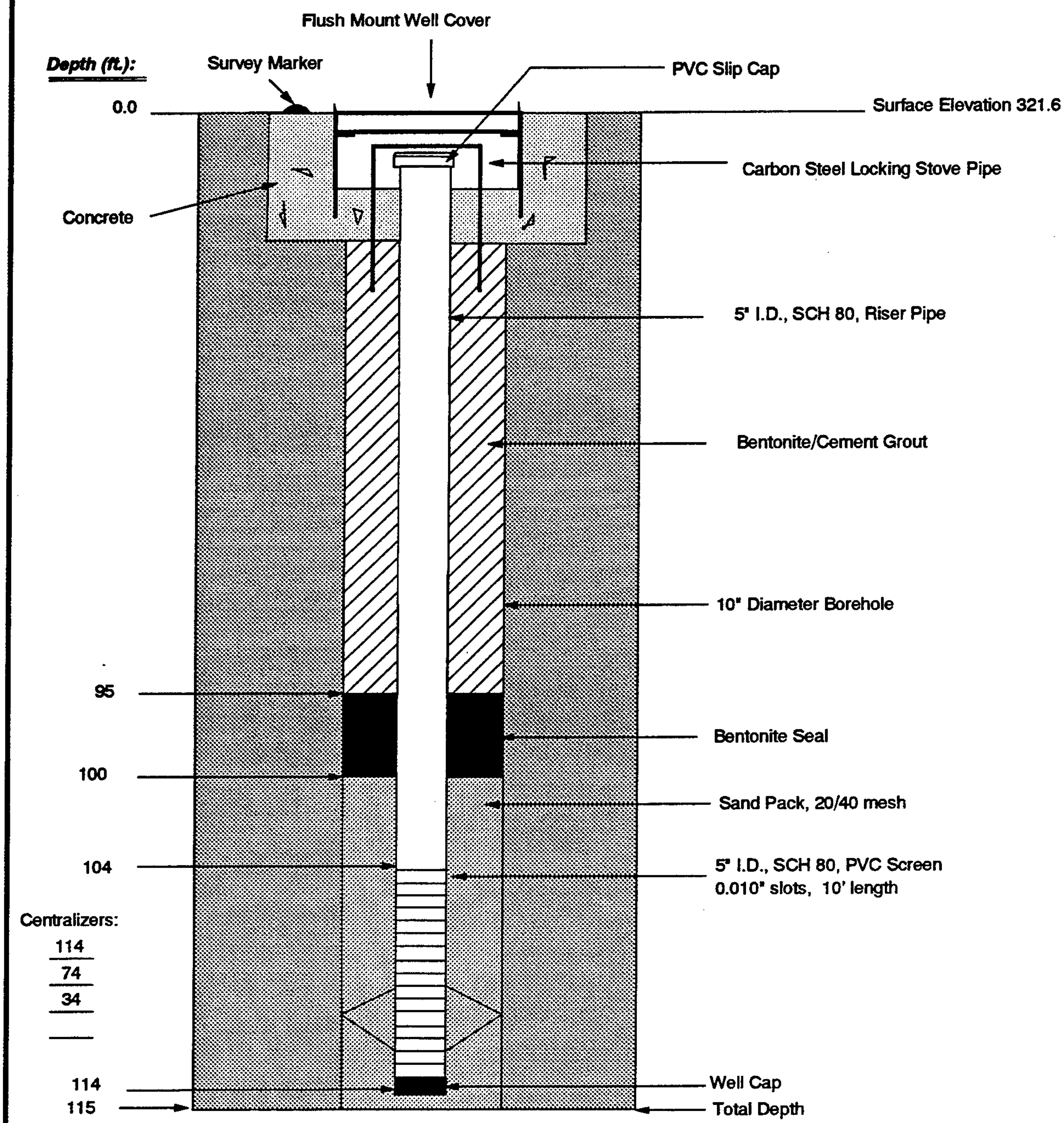
Facility Fresno ANG Base, Fresno, California

Job No. 409724

FRESNO\MWBP-05C\mb\10-10-94

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



Drilling Starter 11/15/93

Well Installed 11/16/93

Developed 11/21/93

Drilling Co. Water Development Corp.

Notes:

MONITORING WELL CONSTRUCTION DIAGRAM

Well No. MWBP-06B

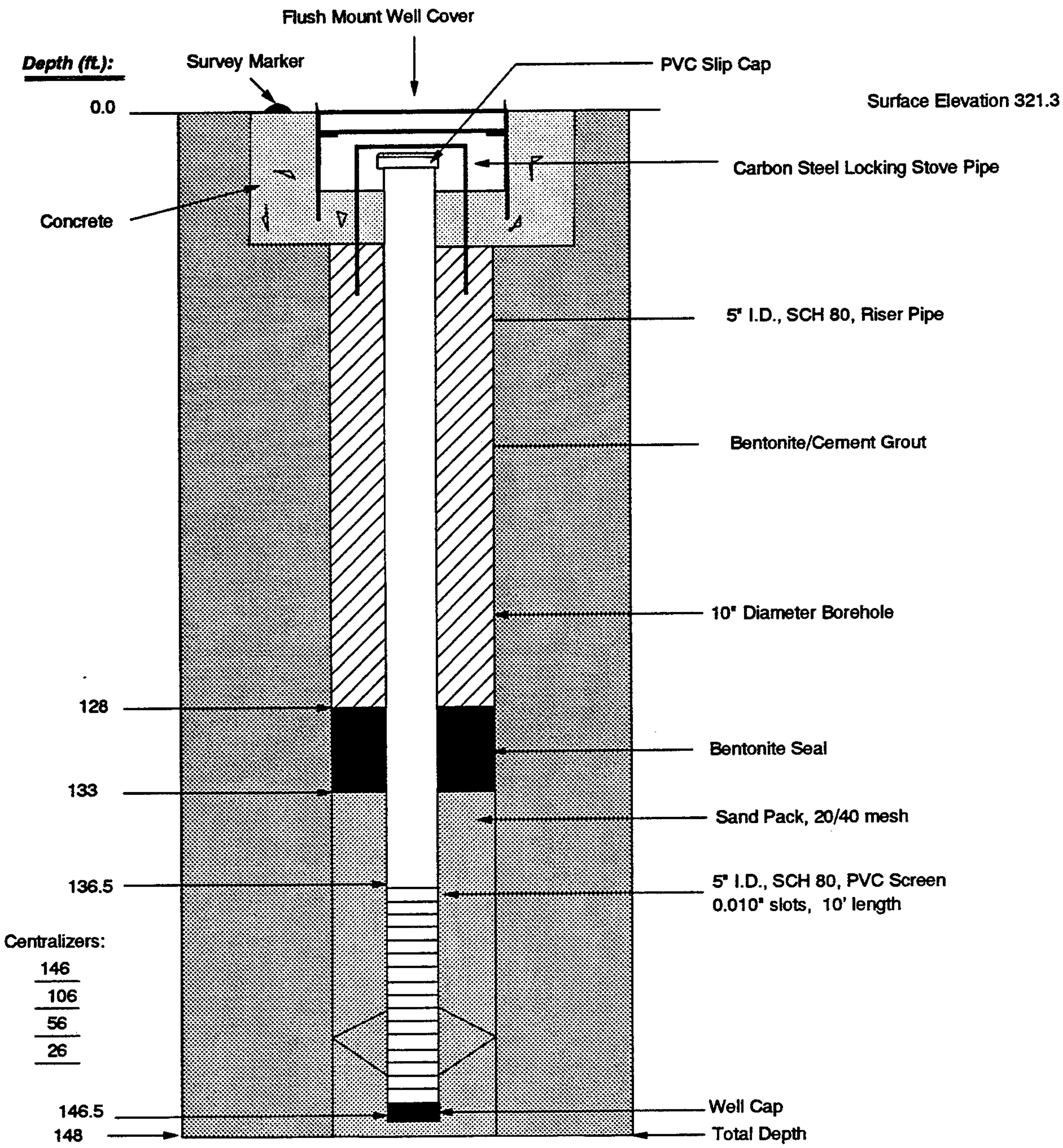
Facility Fresno ANG Base
Fresno, California

Job No. 409724

FRESNO\MWBP-06B\mb\10-10-94

INTERNATIONAL
TECHNOLOGY
CORPORATION

(Not To Scale)



MONITORING WELL CONSTRUCTION DIAGRAM

Drilling Starter 11/9/93

Well Installed 11/10/93

Developed 11/20/93

Drilling Co. Water Development Corp.

Notes:

Well No. MWBP-06C

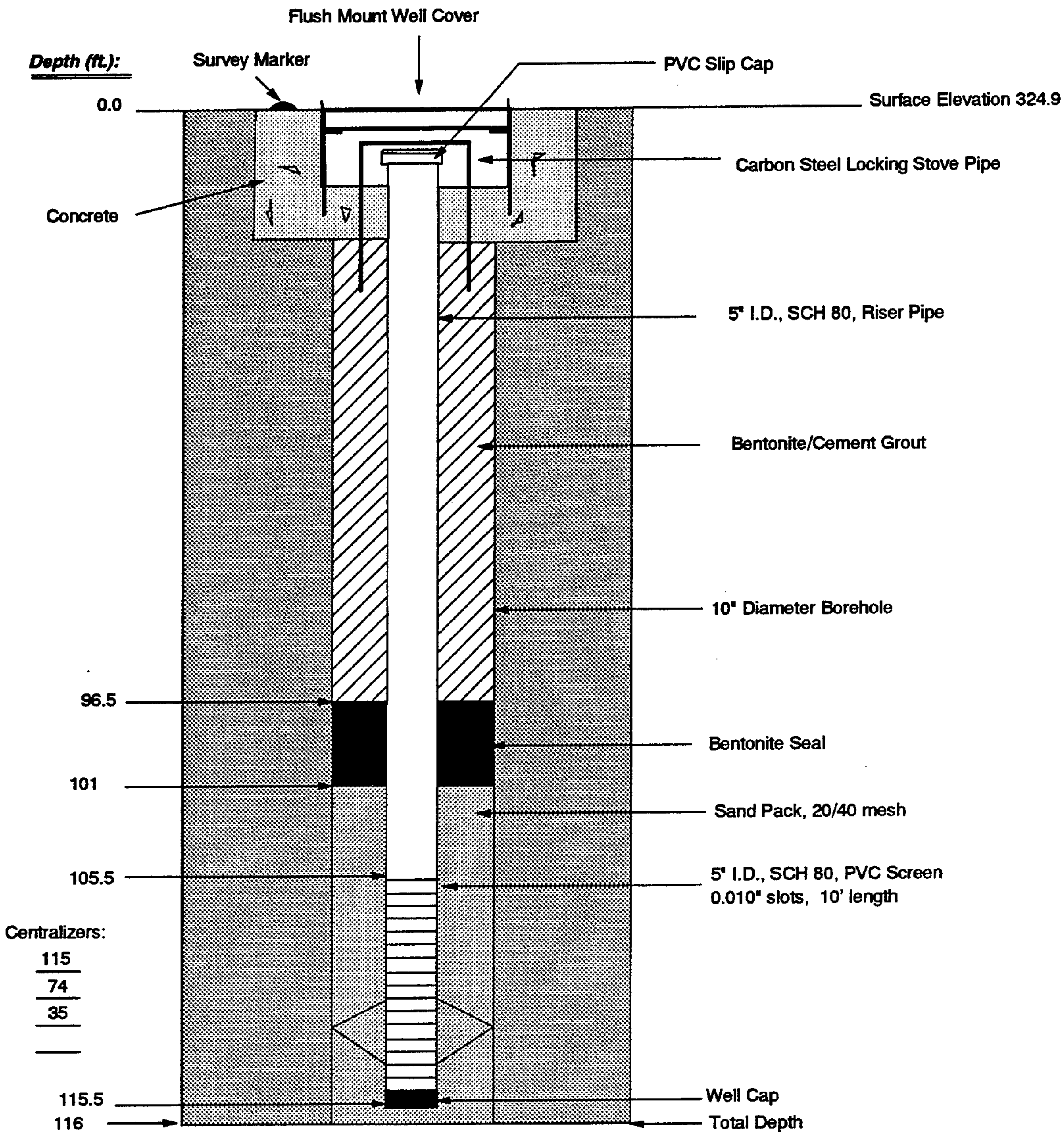
Facility Fresno ANG Base
Fresno, California

Job No. 409724

FRESNO\MWBP-06C\mb\10-10-94

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



MONITORING WELL CONSTRUCTION DIAGRAM

Well No. MWBP-09B

Facility Fresno ANG Base
Fresno, California

Job No. 409724

Drilling Starter 11/5/93

Well Installed 11/5/93

Developed 11/14/93

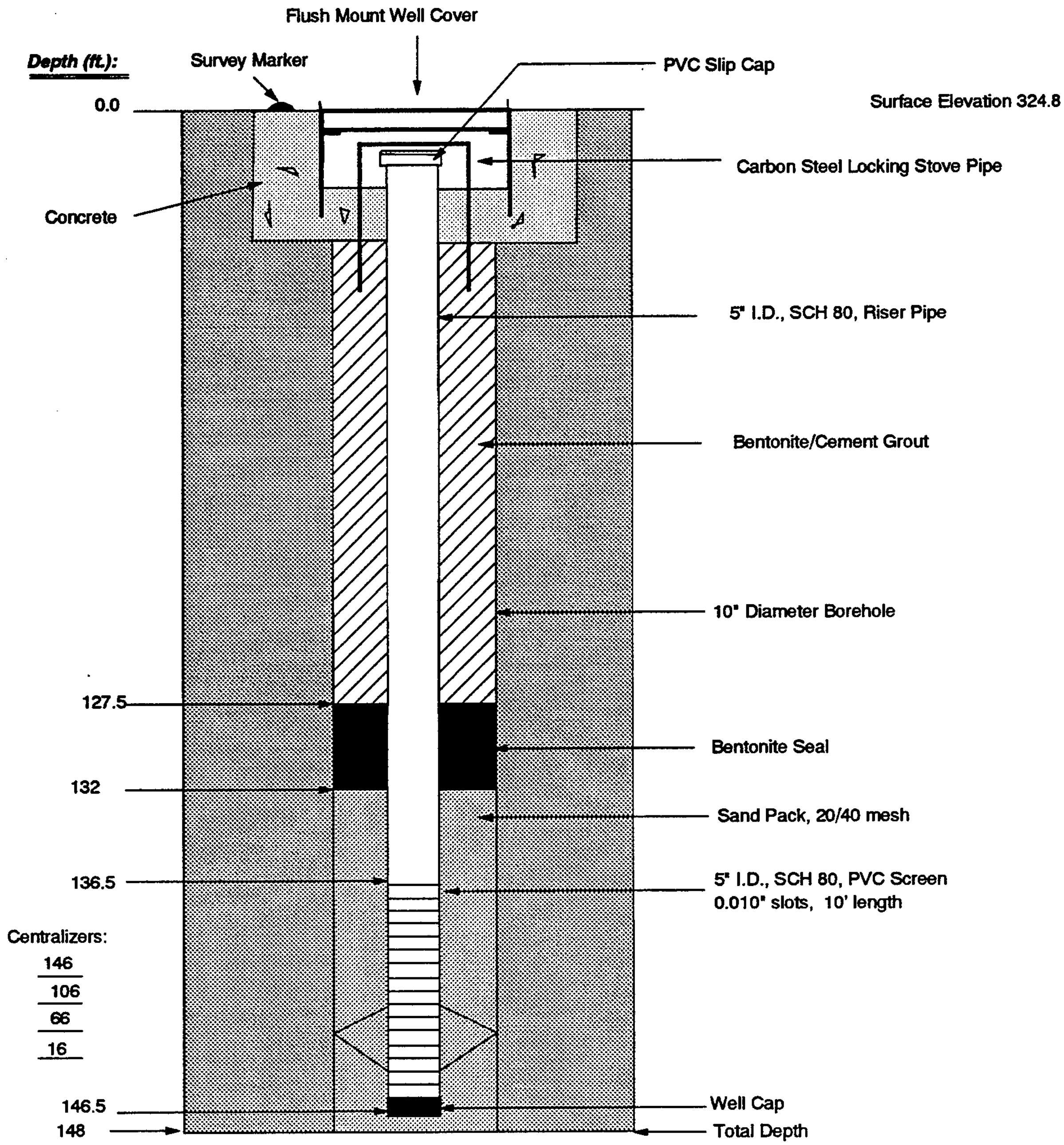
Drilling Co. Water Development Corp.

Notes:

FRESNO\MWBP-09B\mb\10-10-94

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



MONITORING WELL CONSTRUCTION DIAGRAM

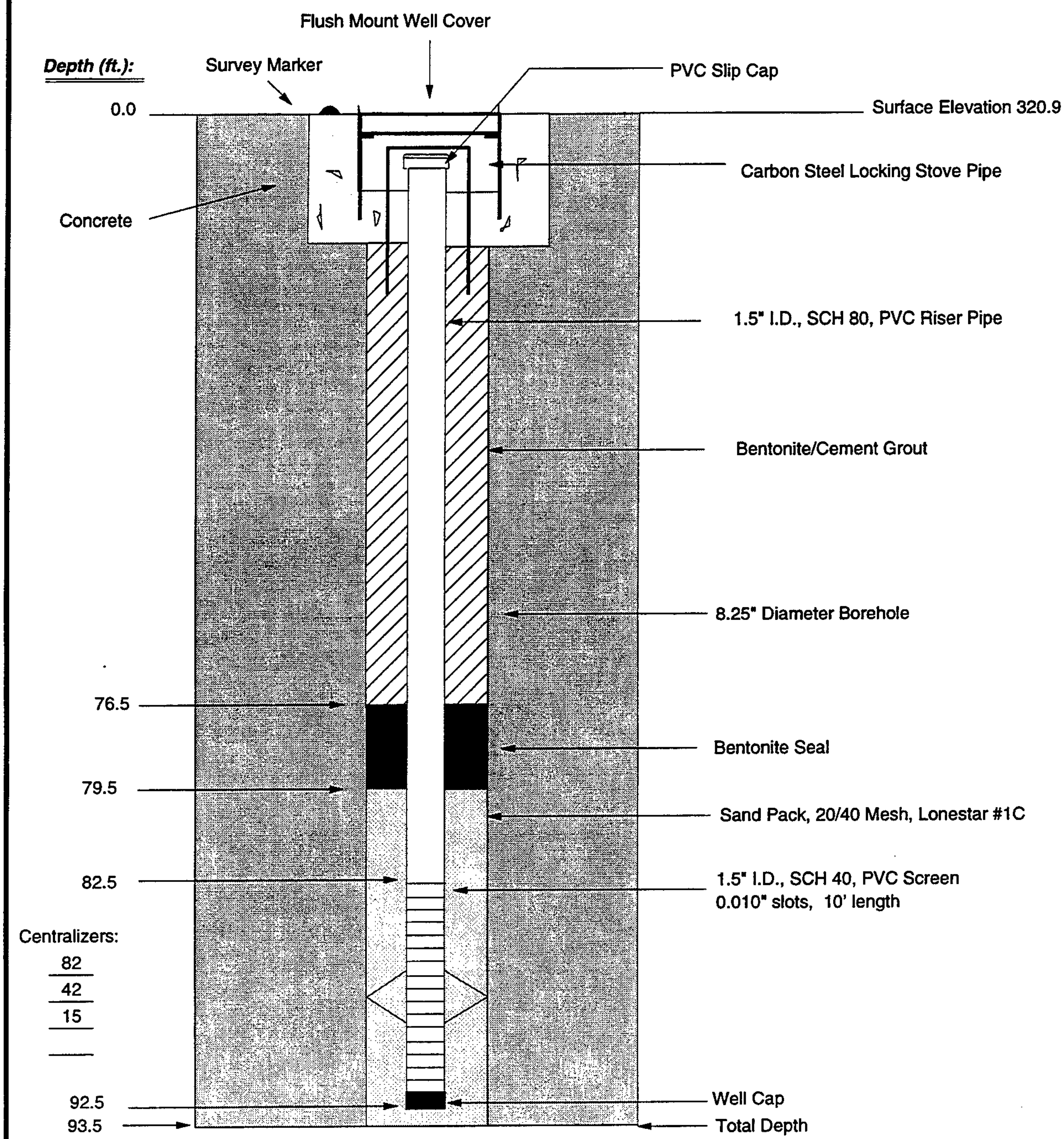
Drilling Starter 11/3/93
Well Installed 11/4/93
Developed 11/14/93
Drilling Co. Water Development Corp.
Notes: ______

Well No. MWBP-09C
Facility Fresno ANG Base
Fresno, California
Job No. 409724

FRESNO\MWBP-09C\mb\10-10-94

INTERNATIONAL
TECHNOLOGY
CORPORATION

(Not To Scale)



MONITORING WELL CONSTRUCTION DIAGRAM

Drilling Starter 3/16/95

Well Installed 3/16/95

Developed ________

Drilling Co. Water Development Corp.

Notes: ________

Well No. P-1

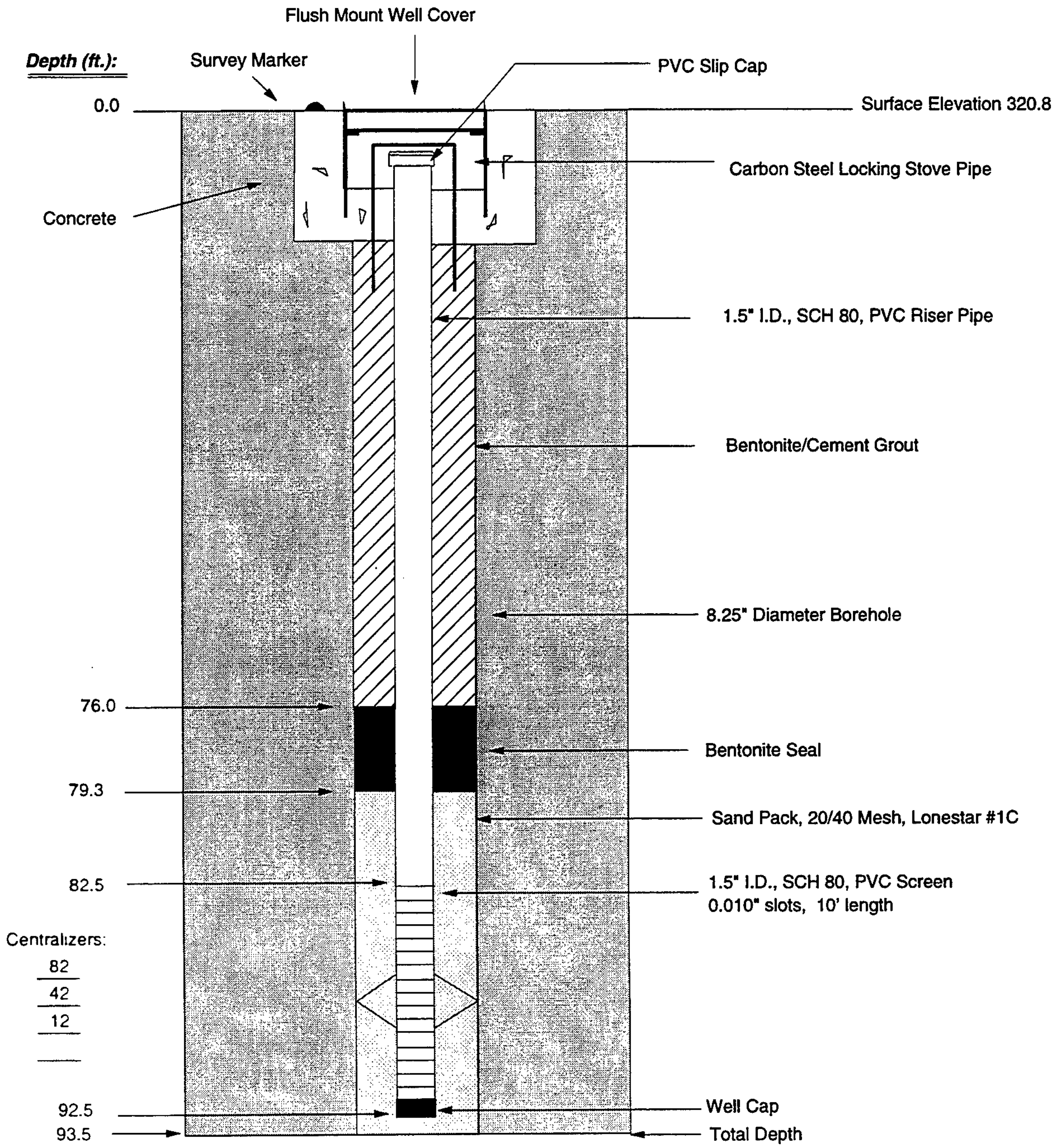
Facility Fresno ANG Base
Fresno, California

Job No. 409724

FRESNO\P-1\mc\10-10-95

INTERNATIONAL
TECHNOLOGY
CORPORATION

(Not To Scale)



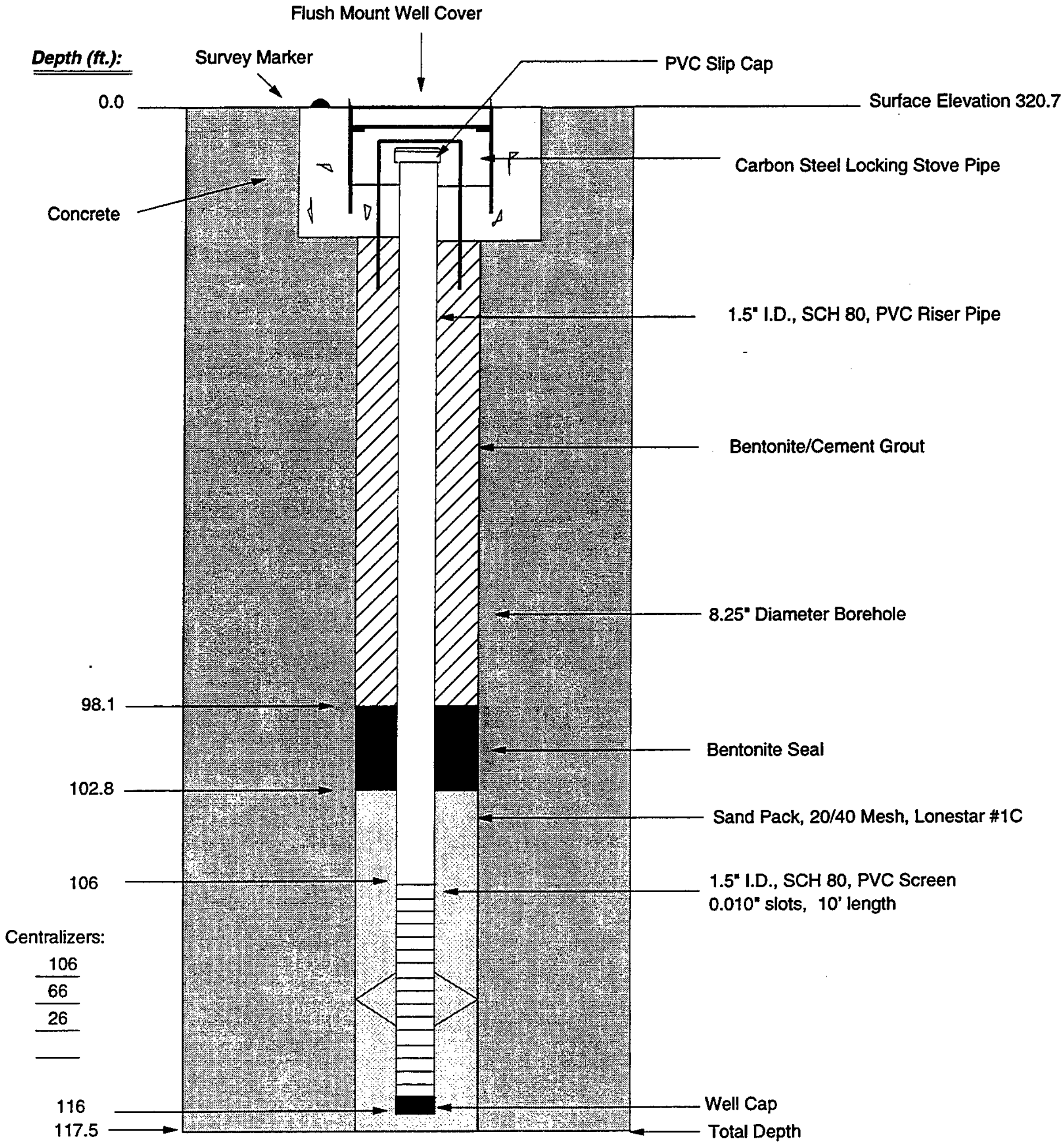
Drilling Starter 3/16-17/95
Well Installed 3/16-17/95
Developed ______
Drilling Co. Water Development Corp.
Notes: ______

MONITORING WELL CONSTRUCTION DIAGRAM

Well No. P-2
Facility Fresno ANG Base
Fresno, California
Job No. 409724

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



Drilling Starter 3/13/95

Well Installed 3/13/95

Developed ________

Drilling Co. Water Development Corp.

Notes: ________

MONITORING WELL CONSTRUCTION DIAGRAM

Well No. P-3B

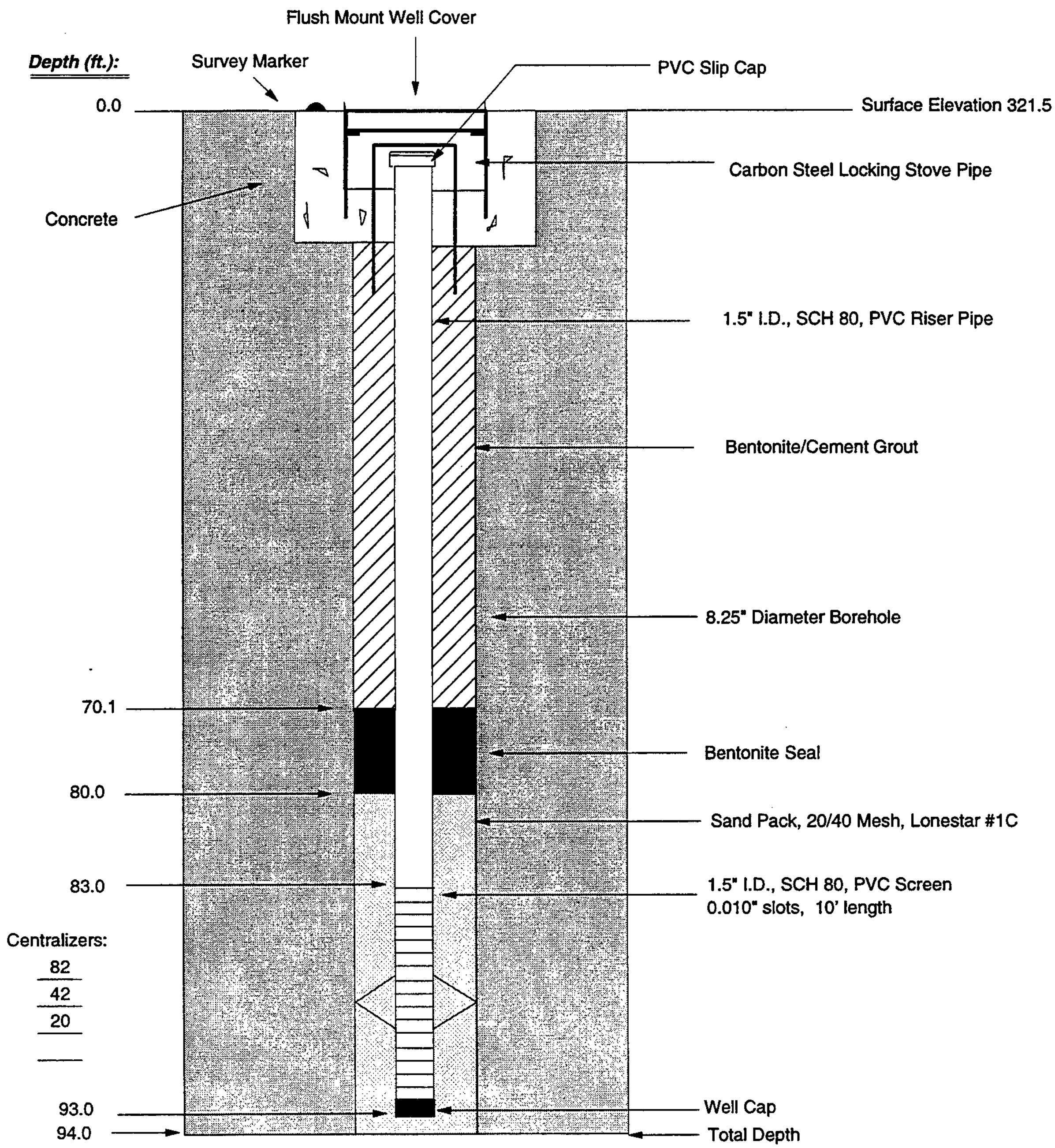
Facility Fresno ANG Base
Fresno, California

Job No. 409724

FRESNO\P-3\mc\10-10-95

INTERNATIONAL
TECHNOLOGY
CORPORATION

(Not To Scale)



Drilling Starter 3/14/95

Well Installed 3/14/95

Developed

Drilling Co. Water Development Corp.

Notes:

MONITORING WELL CONSTRUCTION DIAGRAM

Well No. P-4A

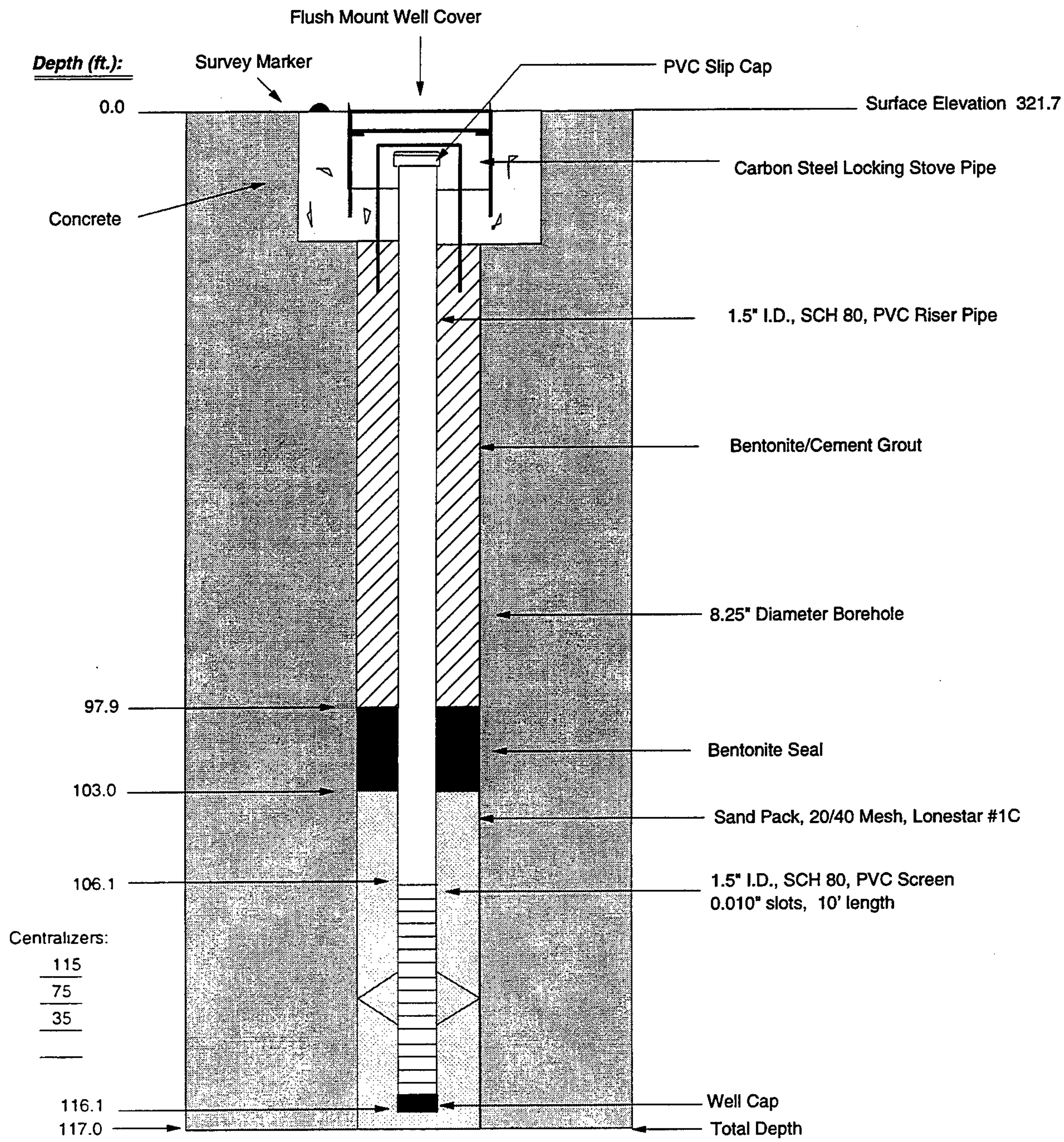
Facility Fresno ANG Base
Fresno, California

Job No. 409724

FRESNO\P-4A\mc\10-10-95

INTERNATIONAL TECHNOLOGY CORPORATION

(Not To Scale)



MONITORING WELL CONSTRUCTION DIAGRAM

Drilling Starter 3/15/95

Well Installed 3/15/95

Developed ______

Drilling Co. Water Development Corp.

Notes: ______

Well No. P-5B

Facility Fresno ANG Base
Fresno, California

Job No. 409724

FRESNO\P-5B\mc\10-10-95

APPENDIX C

SLUG TEST INFORMATION

Appendix C
Slug Test Analysis Discussion

The method chosen to analyze the slug test data from the six wells installed at the Fresno Air National Guard (ANG) Base during the Site 5 focused remedial investigation was the Bouwer and Rice method. It was chosen because the uppermost aquifer of concern is unconfined and because the water level fluctuates within the screened interval.

Each well tested was four inches in diameter, with a 12-inch diameter borehole. Rising head (slug out) tests were conducted, and drawdown measurements were taken with a pressure transducer and data logger (as discussed in the body of this report).

The Bouwer and Rice equation is:

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2L_e}(1/t)\ln(y_o/y_t) \qquad \text{eq. (1)}$$

where:

K = hydraulic conductivity (L/T)

r_c = radius of well casing (L), see following discussion

L_e = length of well screen open to aquifer (L)

y_o = drawdown at time, t = 0 (L)

y_t = drawdown (L) at some later time, t (T)

$\ln(R_e/r_w)$ is a calculated term that is discussed in following text (Bouwer and Rice, 1976).

$\ln(R_e/r_w)$ is a term describing the effective head loss dissipation into the aquifer. Bouwer and Rice empirically derived the following equation to calculate this term for a partially penetrating well:

where:

r_w = radius of the well borehole (L)
H = saturated thickness of the aquifer (L)

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B\ x\ \ln\left(\frac{H-L_w}{r_w}\right)}{(L_e/r_w)}\right]^{-1} \qquad \text{eq. (2)}$$

A and B = graphically derived constants (unitless)
L_w = length of well screen below the water table (L).

The term H was obtained from reports and local well logs that indicate that a fairly continuous retarding layer is present at a depth of approximately 105 feet (as illustrated schematically in Figure 1). The depth to water in a particular well was subtracted from 105 feet to find H. Because the water level fluctuated within the screened interval in all 6 wells at the Base, the terms L_e and L_w are equivalent (see Figure 1).

Because the water level is within the screened interval, the term r_c in Equation 1 has to be adjusted to account for the porosity of the filter pack material. This is done with the following equation:

$$r_c = \left[r_c^2 + n(r_w^2 - r_c^2)\right]^{1/2} \qquad \text{eq. (3)}$$

where:

n is the filter pack porosity, and is assumed to be 0.35.

The empirical constants A and B are obtained from the graph in Figure 2. The quotient L_e/r_w is calculated and the values are read from the x-axis to their respective curves, and across to each vertical axis.

At this point, the terms in Equation 1, $\ln(R_e/r_w)$, L_e, and r_c, have been determined. To find the drawdown term (y_o, y_t, and t), a graph is constructed. Drawdown (y) is on the logarithmic vertical axis, with elapsed time on the arithmetic horizontal axis. An example is shown in Figure 3. In general, the data points lay in three distinct lines. The earliest (and steepest) line usually represents water drainage into the well from the filter pack. The second line is most indicative of the aquifer formation surrounding the well, and the third line (gentlest slope) shows a deviation from the straight line as the drawdown around the well becomes small relative to the initial drawdown (Bouwer, 1989). Some interpretation of these lines

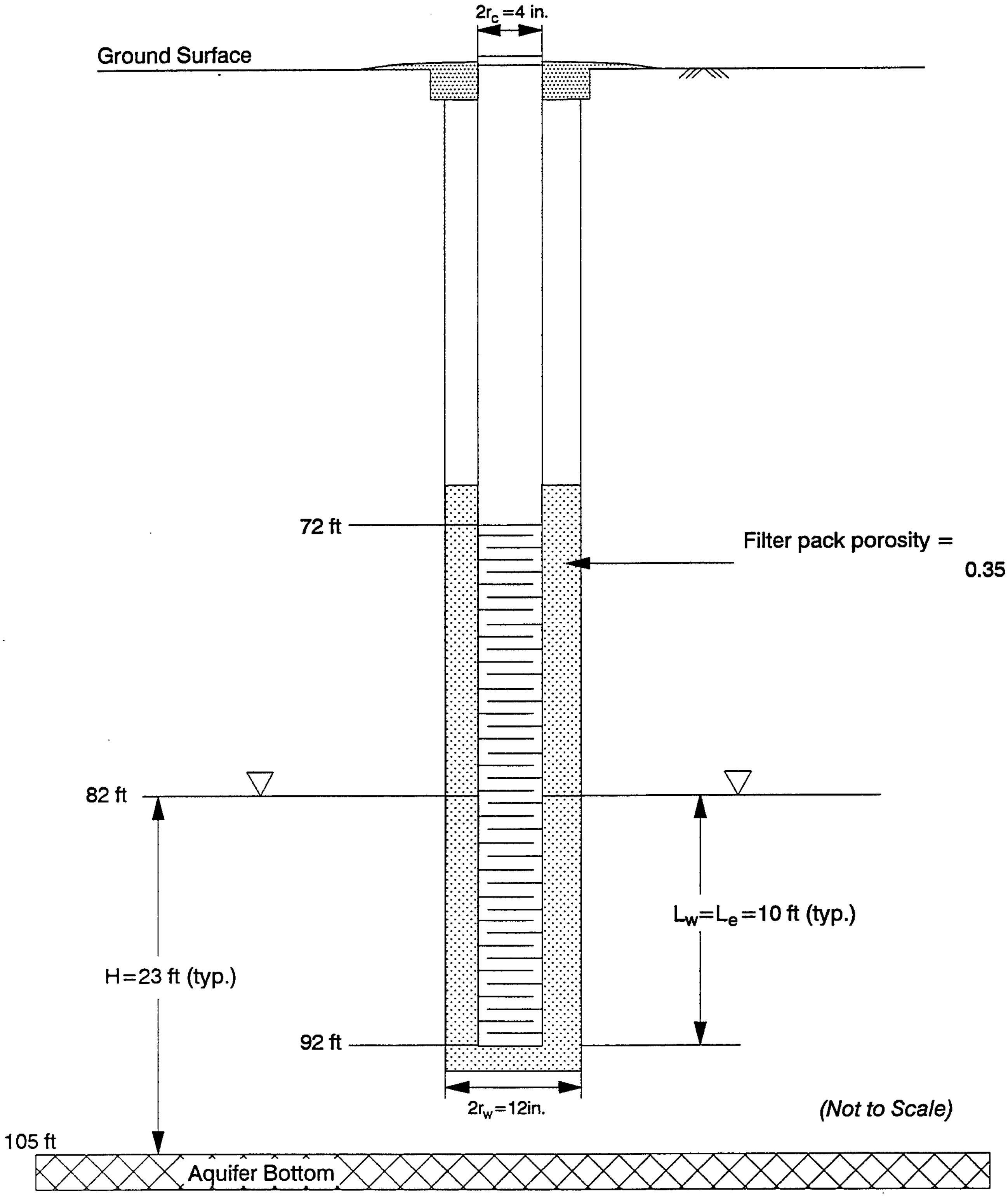
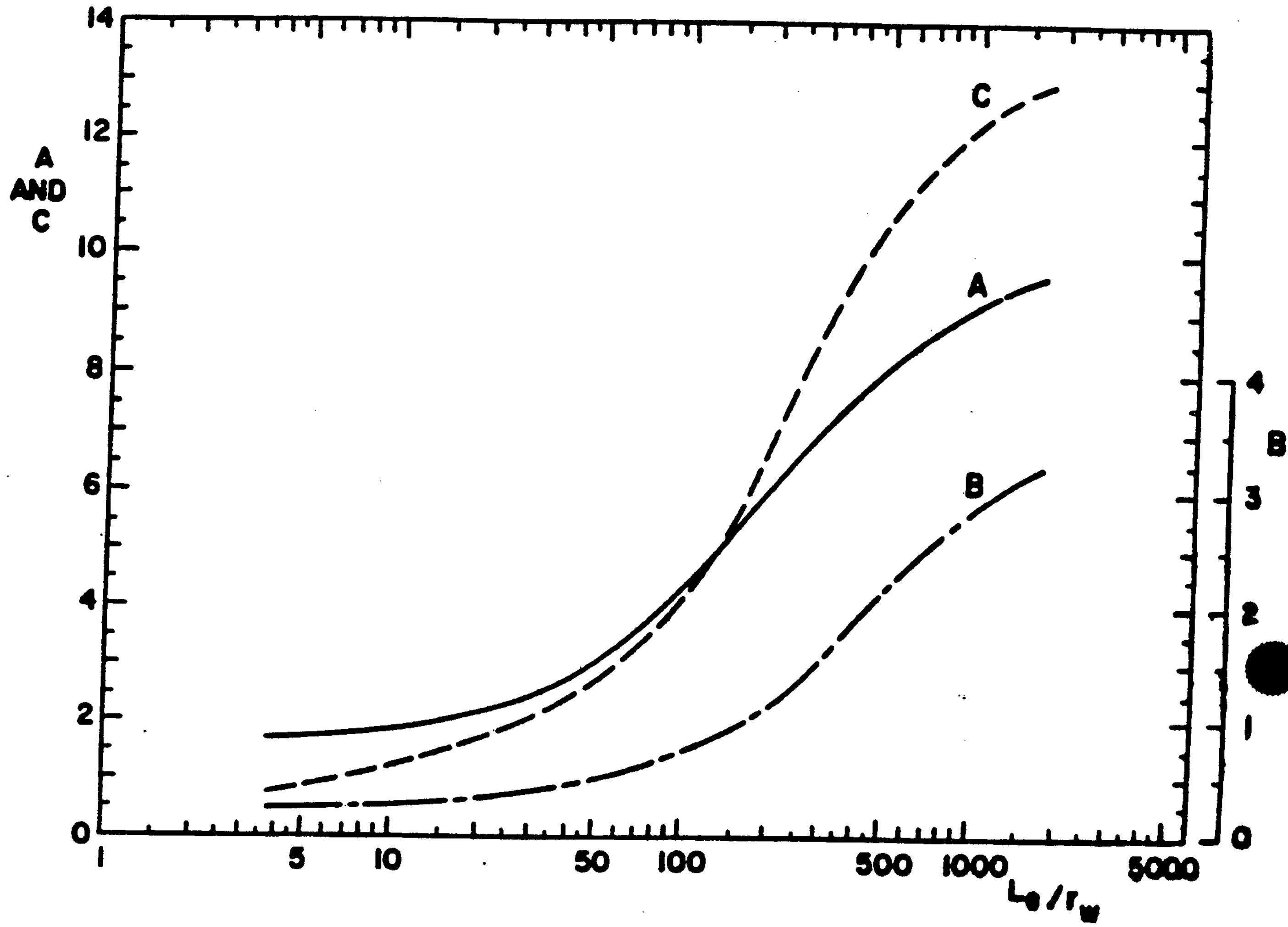


FIGURE 1

Typical Well Geometry and Terms for the Bouwer & Rice Equation

INTERNATIONAL TECHNOLOGY CORPORATION



Source: Bouwer, H. and R. C. Rice, 1976, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells" Water Resources Research, V.12, No. 3, pp. 423–428.

FIGURE 2

Dimensionless Parameters A, B, and C as a Function of L_e/r_w for Calculating $\ln(R_e/r_w)$

must be made. A straight line is projected from the data curve of the second straight line portion to the y-axis; the intercept is the value for y_o. Any other point along this same straight line is chosen for the value of y_t at its corresponding time, t on the x-axis. A value for the hydraulic conductivity, K, can then be calculated using eq. (1). An example calculation is provided in Appendix F of the site investigation report (IT, 1992a).

Each slug test was analyzed, and the results are summarized in Table 1. Also included in this Appendix are data summary sheets (Worksheets 1 through 5) and data graphs (Graphs 1 through 5). The summary sheets list all the pertinent measurements and calculations used to calculate K for each test. The actual field data and choices for y_o, y_t, and t are presented on the graphs. The slug test conducted in well MWBP-12 did not provide sufficient data with which to calculate a K value. Very little drawdown was recorded and recovery was virtually instantaneous. Therefore, no calculation was possible and no data are presented herein.

The geometric mean value for hydraulic conductivity from these tests is approximately 24 feet/day, with the values ranging from 17.3 to 40.1 feet/day (Table 1). These values are similar to those obtained from slug tests performed on 11 other wells across the western portion of the Base in 1990 (MW2-01, MW2-02, MW2-03, and MWBP-01 through MWBP-08). The range of hydraulic conductivity values of the 11 wells is 2.5 to 81.5 feet/day, with a geometric mean of approximately 31 feet/day (IT, 1992a, Appendix F). The range of values, and the mean of the data sets, show good agreement.

References

Bouwer, H., and R. C. Rice, 1976, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells," ***Water Resources Research***, V. 12. No. 3, p. 423-428.

Bouwer, H., 1989, "The Bouwer and Rice Slug Test - An Update," ***Ground Water***, Vol. 27, No. 3, p. 304-309.

IT Corporation, 1992, ***Site Investigation Report for the 144th Fighter Interceptor Wing, California Air National Guard, Fresno Air Terminal, Fresno, California***.

Worksheet 1
Slug Test Analysis Data Sheet
Well ID MW5-01

Flush-mounted well? Yes
If no, well casing stickup height ____ ft
Borehole radius, r_w: 0.5 ft
Well casing radius: 0.167 ft
Porosity of filter pack, n: 0.35
Adjusted r_c: 0.325 ft from Eq. (3); $r_c^2 = 0.106\ ft^2$

Depth to water (TOC): 80.25 ft(a)
Depth to top of screen (TOC): 70.5 ft
Measured depth of well (TOC): 90.45 ft(b)
Depth to aquifer bottom (TOC): 105 ft(c)

$H = (c) - (a) = 24.75$ ft
$L_w = L_e = (b) - (a) = 10.2$ ft
$L_e/r_w = 20.4$

From Figure 2: A = 2.1
B = 0.3

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln\left(\frac{10.2}{0.5}\right)} + \frac{2.1 + 0.3 \times \ln\left(\frac{24.75-10.2}{0.5}\right)}{\left(\frac{10.2}{0.5}\right)}\right]^{-1} = 1.93 \qquad \textbf{from eq. (2)}$$

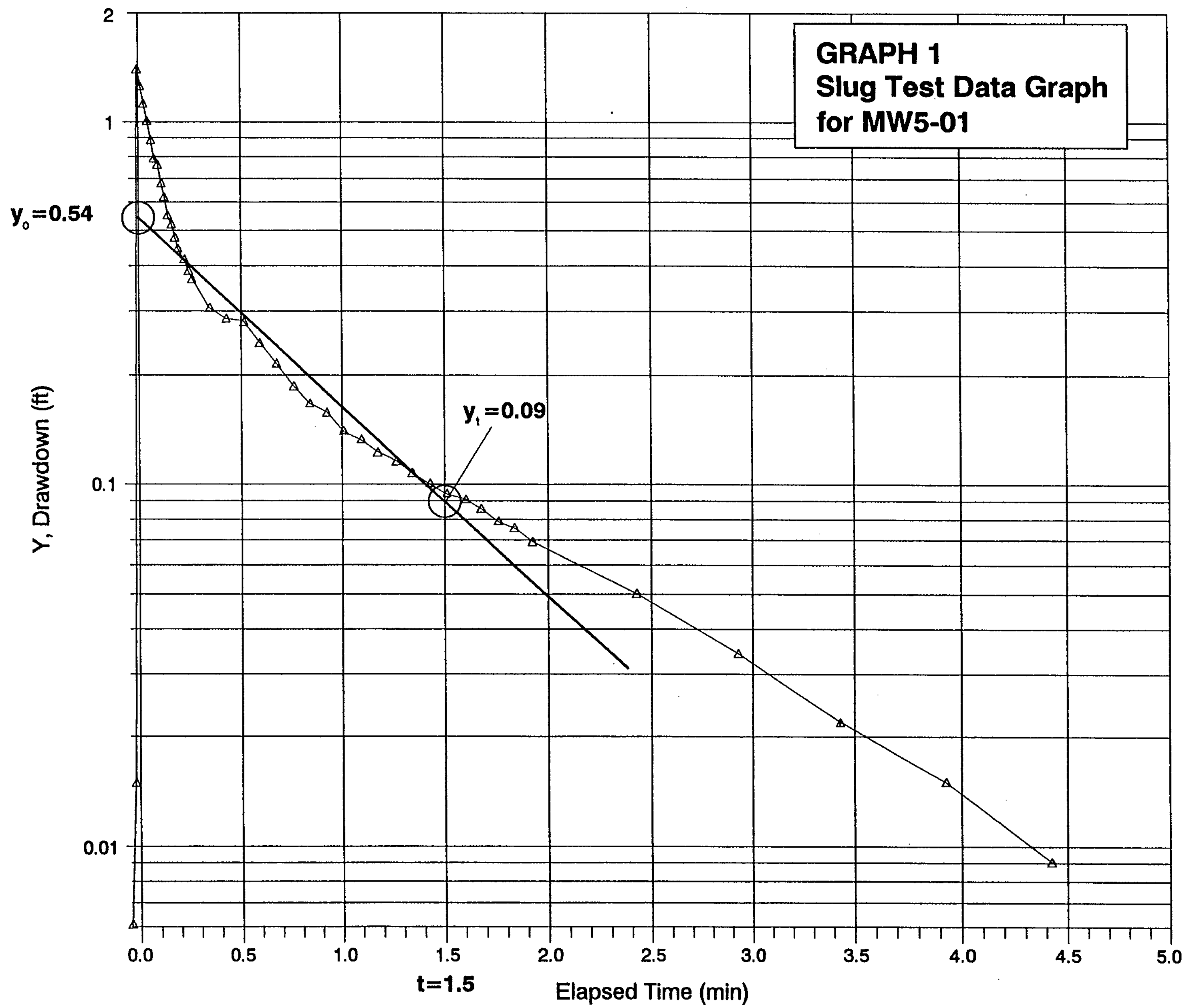
From Graph 1: $y_o = 0.54$ ft
$y_t = 0.09$ ft at time, t = 1.5 minutes

$$K = \frac{0.106ft^2\ x\ 1.93}{2\ x\ 10.2ft}\left(\frac{1}{1.15\text{min}}\right)\ln\left(\frac{0.54ft}{0.09ft}\right) \qquad \textbf{from eq. (1)}$$

K = 0.012 ft/min

K = 17.3 ft/day

K = $6.1\ x\ 10^{-3}$ cm/s


GRAPH 1
Slug Test Data Graph
for MW5-01
2
1
0.1
0.01
y_o=0.54
y_t=0.09
Y, Drawdown (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
t=1.5
Elapsed Time (min)

Worksheet 2
Slug Test Analysis Data Sheet
Well ID MW5-02

Flush-mounted well? Yes

If no, well casing stickup height ____ ft

Borehole radius, r_w: 0.5 ft

Well casing radius: 0.167 ft

Porosity of filter pack, n: 0.35

Adjusted r_c: 0.325 ft from Eq. (3); $r_c^2 = 0.106\ ft^2$

Depth to water (TOC): 82.50 ft(a)

Depth to top of screen (TOC): 72.5 ft

Measured depth of well (TOC): 92.8 ft(b)

Depth to aquifer bottom (TOC): 105 ft(c)

$H = (c) - (a) = 22.5$ ft

$L_w = L_e = (b) - (a) = 10.3$ ft

$L_e/r_w = 20.6$

From Figure 2: A = 2.1
B = 0.3

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln\left(\frac{10.3}{0.5}\right)} + \frac{2.1 + 0.3 \times \ln\left(\frac{22.5-10.3}{0.5}\right)}{\left(\frac{10.3}{0.5}\right)}\right]^{-1} = 1.95$$ **from eq. (2)**

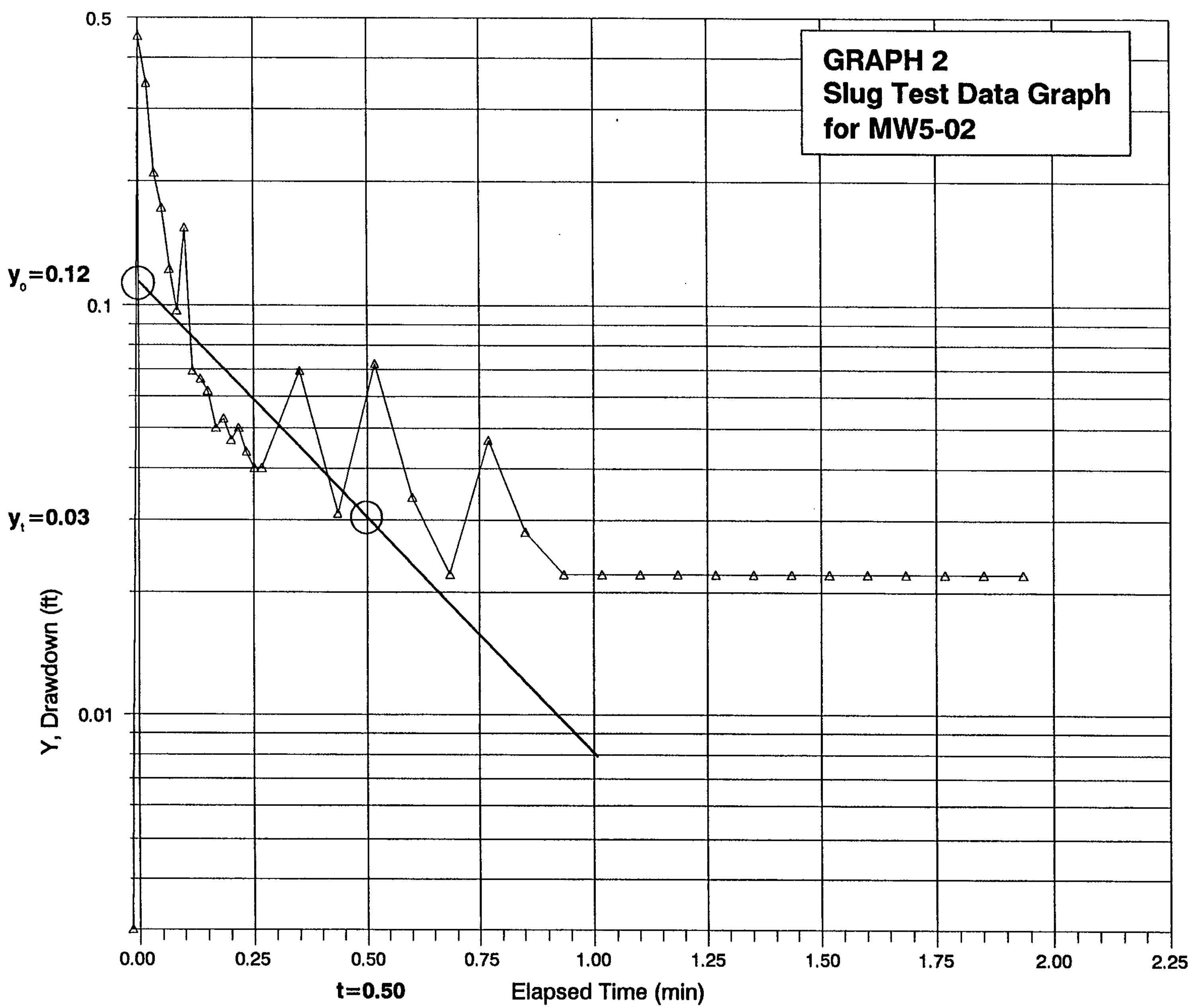
From Graph 1: $y_o = 0.12$ ft
$y_t = 0.03$ ft at time, t = 0.50 minutes

$$K = \frac{0.106ft^2\ x\ 1.95}{2\ x\ 10.3ft}\left(\frac{1}{0.50min}\right)\ln\left(\frac{0.12ft}{0.03ft}\right)$$ **from eq. (1)**

K = 0.028 ft/min

K = 40.1 ft/day

$K = 1.4 \times 10^{-2}$ cm/s


GRAPH 2
Slug Test Data Graph
for MW5-02
0.5
y_o=0.12
0.1
y_t=0.03
0.01
Y, Drawdown (ft)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
t=0.50
Elapsed Time (min)

Worksheet 3
Slug Test Analysis Data Sheet
Well ID MWBP-09

Flush-mounted well? Yes

If no, well casing stickup height ____ ft

Borehole radius, r_w: 0.5 ft

Well casing radius: 0.167 ft

Porosity of filter pack, n: 0.35

Adjusted r_c: 0.325 ft from Eq. (3);

$r_c^2 = 0.106\ ft^2$

Depth to water (TOC): 79.45 ft(a)

Depth to top of screen (TOC): 74 ft

Measured depth of well (TOC): 91 ft(b)

Depth to aquifer bottom (TOC): 105 ft(c)

H = (c) - (a) = 23.55 ft

$L_w = L_e$ = (b) - (a) = 11.55 ft

$L_e/r_w = 23.1$

From Figure 2: A = 2.25

B = 0.35

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln\left(\frac{11.55}{0.5}\right)} + \frac{2.25 + 0.35 \times \ln\left(\frac{25.55-11.55}{0.5}\right)}{\left(\frac{11.55}{0.5}\right)} \right]^{-1} = 2.01$$ **from eq. (2)**

From Graph 1: $y_o = 0.24$ ft

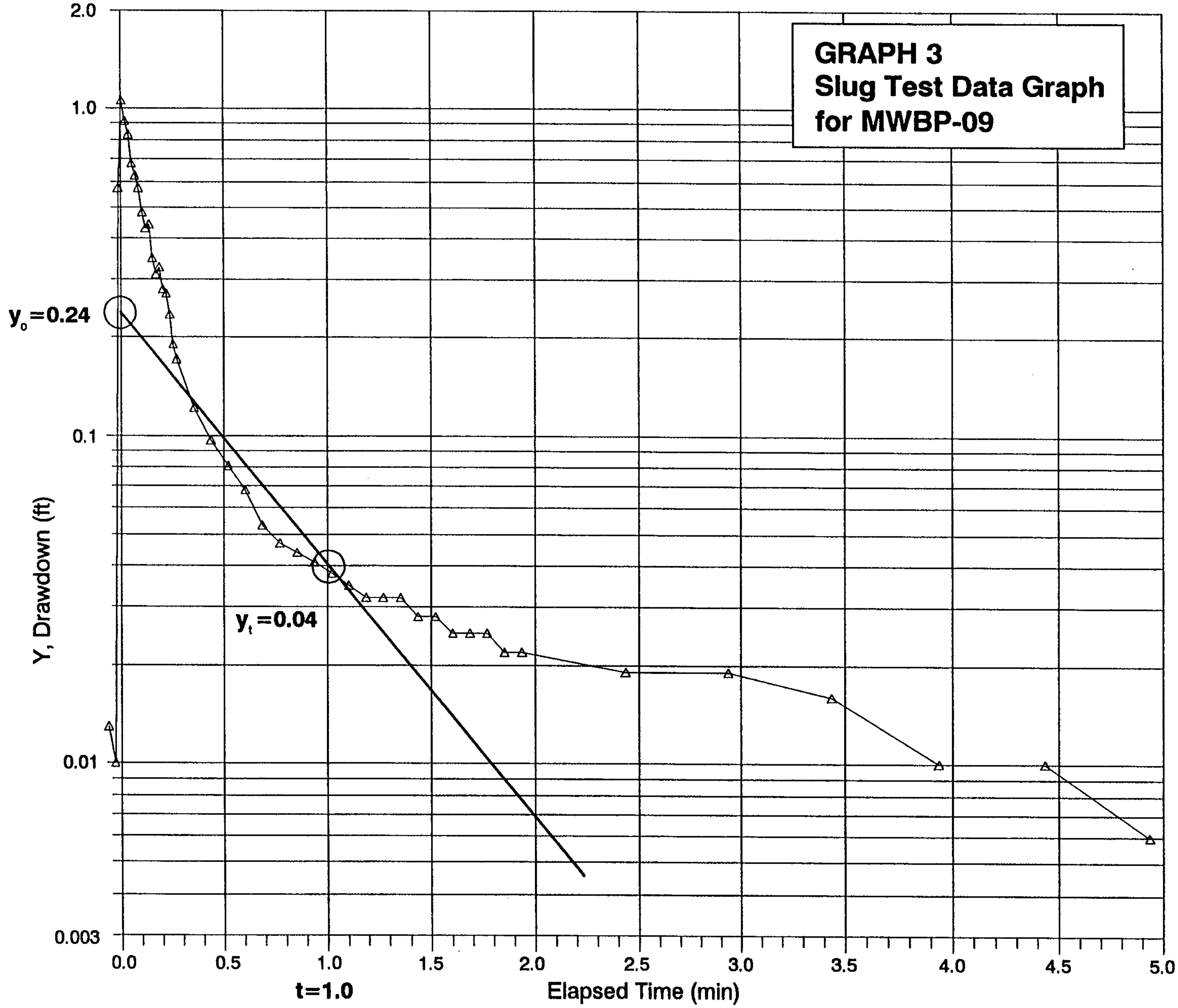
$y_t = 0.04$ ft at time, t = 1 minutes

$$K = \frac{0.106ft^2\ x\ 2.01}{2\ x\ 11.5ft}\left(\frac{1}{1min}\right)\ln\left(\frac{0.24ft}{0.04ft}\right)$$ **from eq. (1)**

K = 0.0165 ft/min

K = 23.8 ft/day

K = 8.4 x 10^{-3} cm/s



GRAPH 3
Slug Test Data Graph
for MWBP-09

Worksheet 4
Slug Test Analysis Data Sheet
Well ID MWBP-10

Flush-mounted well? Yes

If no, well casing stickup height ____ ft

Borehole radius, r_w: 0.5 ft

Well casing radius: 0.167 ft

Porosity of filter pack, n: 0.35

Adjusted r_c: 0.325 ft from Eq. (3);

$r_c^2 = 0.106$ ft^2

Depth to water (TOC): 81.48 ft(a)

Depth to top of screen (TOC): 74.5 ft

Measured depth of well (TOC): 93.2 ft(b)

Depth to aquifer bottom (TOC): 105 ft(c)

H = (c) - (a) = 23.52 ft

$L_w = L_e$ = (b) - (a) = 11.72 ft

$L_e/r_w = 23.4$

From Figure 2: A = 2.25
B = 0.35

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln\left(\frac{11.72}{0.5}\right)} + \frac{2.25 + 0.35 \times \ln\left(\frac{23.52-11.72}{0.5}\right)}{\left(\frac{11.72}{0.5}\right)}\right]^{-1} = 2.03$$

from eq. (2)

From Graph 1: $y_o = 0.21$ ft
$y_t = 0.01$ ft at time, t = 1.5 minutes

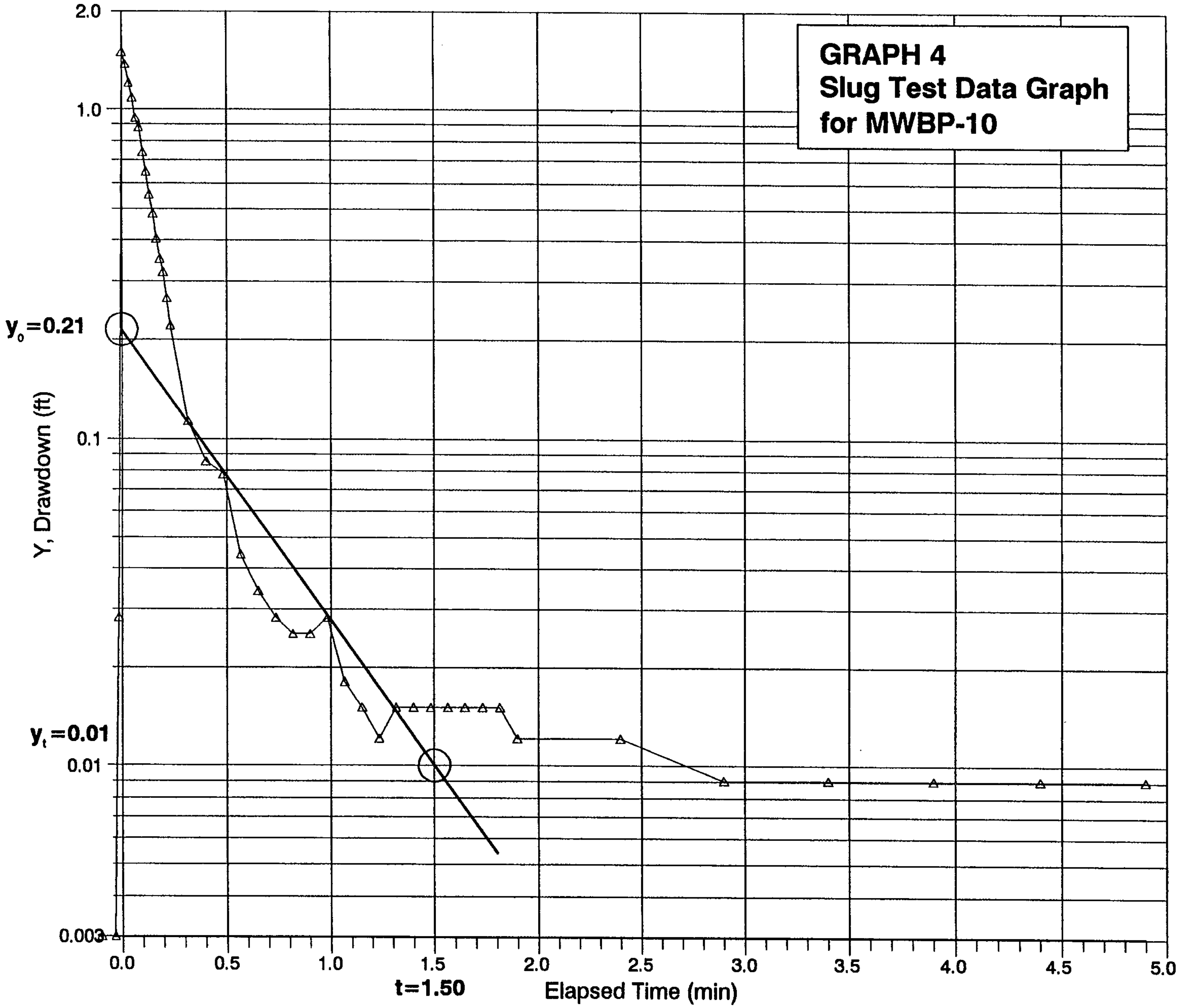
$$K = \frac{0.106ft^2 \; x \; 2.03}{2 \; x \; 11.72ft}\left(\frac{1}{1.5\text{min}}\right)\ln\left(\frac{0.21ft}{0.01ft}\right)$$

from eq. (1)

K = 0.019 ft/min

K = 26.9 ft/day

K = 9.5 x 10^{-3} cm/s


GRAPH 4
Slug Test Data Graph
for MWBP-10
2.0
1.0
0.1
0.01
0.003
y_o=0.21
y_t=0.01
Y, Drawdown (ft)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
t=1.50
Elapsed Time (min)

Worksheet 5
Slug Test Analysis Data Sheet
Well ID MWBP-11

Flush-mounted well? Yes

If no, well casing stickup height ____ ft

Borehole radius, r_w: 0.5 ft

Well casing radius: 0.167 ft

Porosity of filter pack, n: 0.35

Adjusted r_c: 0.325 ft from Eq. (3); $r_c^2 = 0.106\ ft^2$

Depth to water (TOC): 81.80 ft(a)

Depth to top of screen (TOC): 74.5 ft

Measured depth of well (TOC): 94.2 ft(b)

Depth to aquifer bottom (TOC): 105 ft(c)

$H = (c) - (a) = 23.20$ ft

$L_w = L_e = (b) - (a) = 12.35$ ft

$L_e/r_w = 24.7$

From Figure 2: A = 2.3

B = 0.35

$$\ln(R_e/r_w) = \left[\frac{1.1}{\ln\left(\frac{12.35}{0.5}\right)} + \frac{2.3 + 0.35 \times \ln\left(\frac{23.20-12.35}{0.5}\right)}{\left(\frac{12.35}{0.5}\right)}\right]^{-1} = 2.08 \quad \textbf{from eq. (2)}$$

From Graph 1: $y_o = 1.4$ ft

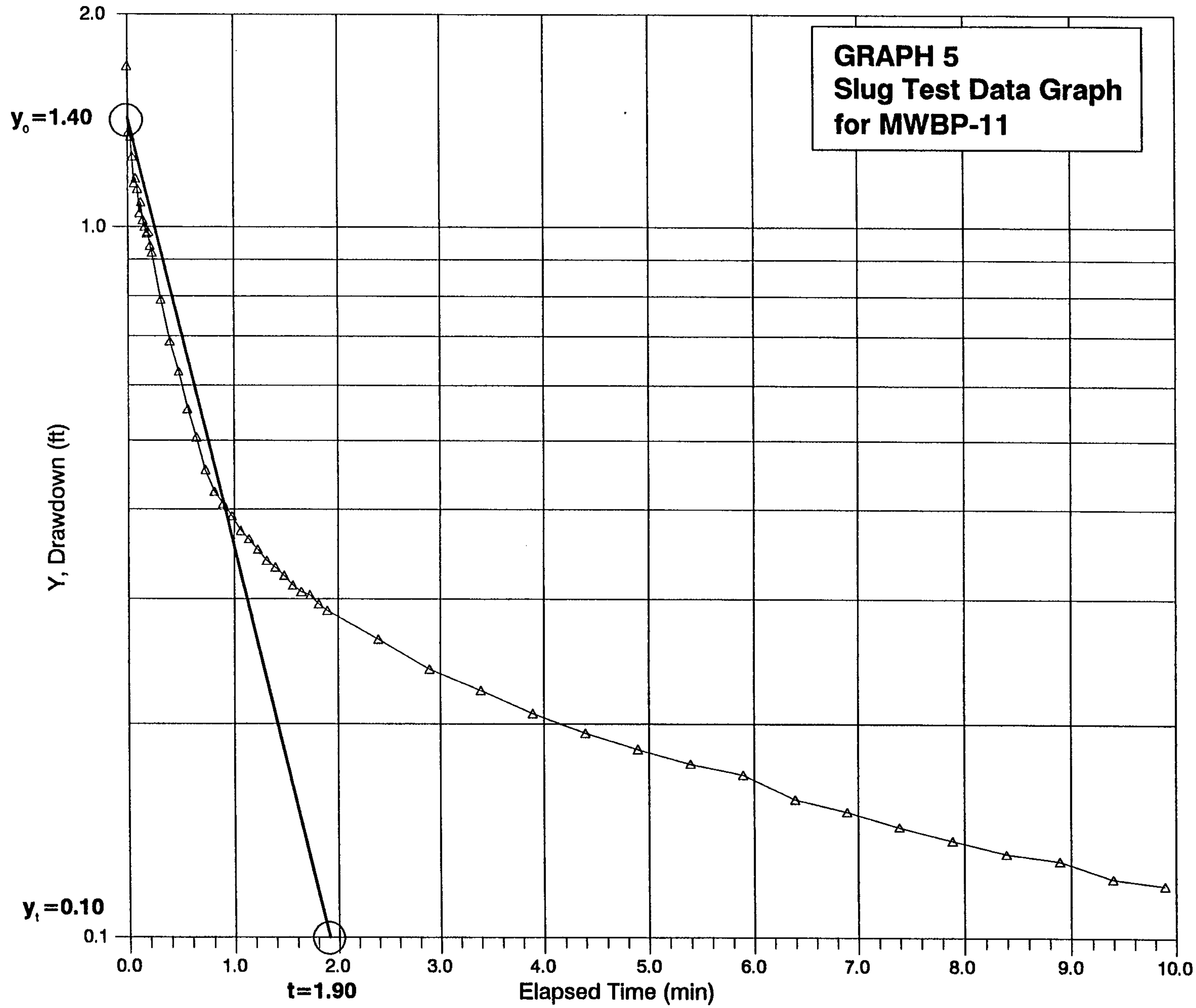
$y_t = 0.1$ ft at time, t = 1.9 minutes

$$K = \frac{0.106ft^2 \ x \ 2.08}{2 \times 12.35ft}\left(\frac{1}{1.9min}\right)\ln\left(\frac{1.4ft}{0.1ft}\right) \quad \textbf{from eq. (1)}$$

K = 0.0124 ft/min

K = 17.9 ft/day

K = 6.3×10^{-3} cm/s


GRAPH 5
Slug Test Data Graph
for MWBP-11
2.0
y_o=1.40
1.0
Y, Drawdown (ft)
y_t=0.10
0.1
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
t=1.90
Elapsed Time (min)

APPENDIX D

ROTARY SONIC DRILLING APPLICATIONS PAPER PRESENTED AT THE EIGHTH NATIONAL OUTDOOR ACTION CONFERENCE, 1994 NATIONAL GROUNDWATER ASSOCIATION MINNEAPOLIS, MINNESOTA

Rotary Sonic Drilling for Environmental Investigations -

Applications To Stratigraphic Characterization and Correlation

T.D. Ault (IT Corp.), S. Logan (IT Corp.),
and A. J. Madaj (HAZWRAP)

Abstract

The rotary sonic, or rotasonic, drilling method is being applied to environmental investigations with increasing frequency. Applications of this technique have been well documented in specific drilling environments. However, concerns have arisen about perceived complications (e.g. core growth) with respect to stratigraphic investigations. The rotary sonic drilling technique was recently applied to provide stratigraphic control and groundwater sampling for a deep aquifer study at the California Air National Guard Base in Fresno, California. The study provided a comparison between sonic core and geophysical logging for determination of stratigraphy.

The rotary sonic drilling technique was used to collect continuous soil core to depths of 250 feet in lithologies that would have proven challenging for many conventional drilling techniques. A series of five exploratory borings were drilled and sampled; two of the borings were geophysically logged. Due to uncertainty associated with core growth (core recovery greater than actual drilled intervals), a comparison of lithologic contact depths was made against the geophysical logging technology. Verification of the sonic core lithologies was accomplished through comparison with resistivity and natural gamma logs. Correlation between the rotary sonic logging and the geophysical methods was, in most cases, excellent.

Verification of the quality of the geologic logs derived from rotary sonic core with the geophysical logs provided confidence in the rotary sonic method. Core growth was observed in the sonic core, but interpolation within drilled intervals was used to correct contact depths. Contact displacement was observed in the core-geophysical log comparison but the observed error was acceptable for the objectives of the investigation.

The success of rotary sonic drilling for stratigraphic exploration and groundwater monitoring network design was clearly demonstrated during this investigation. This project effectively shows that despite some unique characteristics of the sonic coring, the method has strong potential for future environmental investigations. The use of geophysical logging in conjunction with sonic coring is strongly recommended for maximum accuracy in contact depths and lithology determination.

Introduction

A site investigation (SI) has been ongoing since 1990 at the Fresno Air National Guard Base (Base) in Fresno, California (Figure 1). The upper water bearing zone, or water table aquifer, has been investigated and characterized. Groundwater in the vicinity of the Base has been shown to contain low concentrations of chlorinated solvents, trichloroethene (TCE) and tetrachloroethene (PCE), trace concentrations of other chlorinated organic compounds and commonly used agricultural pesticides (ERM-West, 1991 and Borba, 1990). The lateral extent of groundwater contamination at the water table has been well documented (IT, 1992). An investigation was conducted in October, 1993 to examine the vertical extent of groundwater contamination. A method relatively new to environmental investigations, rotary sonic drilling, was applied to the investigation. Rotary sonic drilling has recently been applied to environmental projects (Volk 1993) and was successfully applied to the Fresno Air National Guard Base investigation. The verification of the rotary sonic methods effectiveness in stratigraphic borings is outlined in the focus of the following sections.

The objectives of the investigation were: 1) the identification of water bearing strata, and 2) the determination of the vertical extent of contamination. The investigation program was divided into two tasks: drill and sample a series of exploratory borings; and install the monitoring wells after the data had been evaluated. Geologic information at depth in the vicinity was inadequate, so a better understanding of the subsurface stratigraphy was necessary. The program targeted sand layers which provide pathways for contaminant migration and attempted to determine their lateral continuity. Characterization of the hydrogeologic regime beneath the Base required a two-stepped investigation strategy. The first step was to identify the zones of greatest potential contaminant mobility below the water table aquifer and collect groundwater screening samples using a Hydropunch II[R] sampler. The second step was to verify groundwater quality by installing groundwater monitoring wells. Lithologic control was necessary for both of these tasks. The drilling method needed to facilitate collection of groundwater screening samples as drilling progressed. A drilling method, therefore, was required to provide continuous soil core for visual logging and at the same time allow the collection of groundwater screening samples.

Because the program depended on lithologic information, continuous core to 250 feet below ground surface (bgs) was required. Rotary sonic drilling appeared to represent an effective technique with which to obtain this data. Considering the investigation tasks: lithologic definition, collection of screening samples and the design of a monitoring well network, the rotary sonic appeared to be a suitable drilling method. The amount of data potentially available and it's relative speed made this drilling method worth the potential risks of it's unfamiliarity. However, the quality of the rotary sonic core in the expected soil types was uncertain. Because this technology has not been widely used within the environmental industry, its familiarity was at issue. The quality of the soil core was unknown; that is, its quality in relation to continuous split-spoon sampling, or its comparison to borehole geophysics was not documented. Published information on soil core quality were not available and verification of accuracy was necessary before the data could confidently be used use for lithologic control applications. Therefore, showing that the visual log based on the soil core was reliable and accurate was certainly an issue in the overall program.

Geophysical logging provided the data necessary to evaluate the coring method accuracy and provided additional data for correlation of coarse grain units. Geophysical logs are proven tools for lithologic control and the ability to evaluate lithologic contact depth accuracy from the rotary sonic method could provide necessary confidence to apply it to the project.

Two exploratory soil borings were drilled and logged using both visual geologic and borehole geophysical methods. A comparison between the geologic and geophysical logging methods established that the rotary sonic method delivers the required stratigraphic information and the rest of the program was completed as planned. The interpretation of the upper interval of one boring is provided to illustrate of the methodology, accuracy and uncertainty of the study.

Hydrogeologic Setting

Fresno is located in the east-central part of the San Joaquin Valley, near the foothills and mountains of the Sierra Nevada. The Air National Guard Base is located along the southeastern edge of the Fresno Air Terminal in Fresno, California (Figure 1). The most extensive geomorphic units in the San Joaquin Valley include dissected uplands, low alluvial plains and fans, river floodplain and channels, and overflow lands and lake bottoms. The area surrounding the Base is characterized by compound alluvial fans with intermittent streams (Cehrs et al., 1979). These unconsolidated deposits are divided into an older series ranging in age from Tertiary to Quaternary, and a younger series of Quaternary age. The unconsolidated deposits were derived primarily from the hard crystalline bedrock of the Sierra Nevada. Deposits generally include interbedded clays, silts, sands and gravels of varying thicknesses. Underlying the Base are younger Quaternary age deposits. In general, these deposits consist of older alluvium, lacustrine and marsh deposits, younger alluvium and flood-basin deposits (Page and LeBlanc, 1969).

Coarse-grained sediments at the Base occur generally in northeast-southwest trending elongated sand bodies resulting from deposition in ephemeral stream channels that have shifted over time (Cehrs et al., 1979). In the Fresno area, groundwater flows generally to the southwest and preferentially through coarse-grained channel deposits. The water table beneath the Base lies at a depth of approximately 80 feet. Groundwater flows at an average rate of 130 feet per year. The water table aquifer consists of silty sands, interbedded with silts and sandy silts. The SI at the Base did not, until this most recent program, penetrate through the water table aquifer, so deeper information was not available. Based on regional well logs, it was thought that several sand and gravel beds existed between 100 and 250 feet (bgs), but their depths, thicknesses and continuity in the Base vicinity was not determined.

Field Activities

A field program was designed to simultaneously drill exploratory borings, collect groundwater screening samples and test the rotary sonic method with more traditional geophysical logging methods. Two exploratory soil borings, EXB-01 and EXB-02 were drilled and logged using both visual geologic and borehole geophysical methods. A comparison between the geologic and geophysical logging methods was made in order to determine the adequacy of the rotary sonic method. The comparison established that the rotary sonic method was capable of delivering the required stratigraphic information and the decision was made to proceed with the program as planned. The remaining three borings EXB-03 through EXB-05 were drilled and logged using visual geologic logging only. No geophysical logging was performed on these remaining borings. A discussion of the comparisons made between rotary sonic coring method and geophysical logging for the upper interval of EXB-01 is provided below. The interval presents a representative example of the methodology, accuracy and uncertainty involved in the comparison of the two methods of stratigraphic identification and correlation.

Exploratory Borings

A total of five exploratory borings were planned to an average depth of 250 feet (ft) below ground surface (bgs). The rotary sonic drilling services were performed by Water Development

Corporation. Borings EXB-01 through EXB-05 are shown on Figure 2, with borings EXB-1 and EXB-2 located in the northeastern corner of the figure. Each boring was continuously cored with the rotasonic drilling rod used as the core barrel. The core barrel was 4.25-inch outside diameter (OD) and 3.75-inch inside diameter (ID). Since the drill rod was also the core rod, the entire drill string had to be removed from the borehole to retrieve the core. Core run lengths varied from five to 30 feet before the core was retrieved. During drilling, the core rod was advanced and a six-inch OD steel outer casing was vibrated and washed over the core rod. The six-inch casing was advanced to within two feet of the bottom depth of the bit. This was done to seal off upper drilled intervals and to prevent the borehole from collapsing. The size differential between the outer casing (ID) and drill rod (OD), allowed the use of potable water to wash out the material from the annulus. Care was taken to determine if any vertical intrusion of water had occurred into the soil core.

Geologic Core Logging Methods

Core was retrieved by removing the entire length drive casing and extruding the core from the drill rod into PVC troughs. The core was extruded using the vibrating action from the rig. At times, water pressure was added to the top of the core to assist in forcing it from the rod. Geologic logging was accomplished through visual examination of the core. Classification was made using to the Unified Soil Classification System (USBR 5006-86). Geologic logging was complicated by two factors unique to the rotary sonic method: core growth and rind formation.

Core growth results in the retrieval of core longer than the drilled interval. Core expansion was often observed, with a 10-foot core run potentially returning up to 20 feet of core. This was due to a number of factors. First, the physical process of extruding the core from the rod using vibration could cause core growth (extrusion stretch). The observation of the physical character of the core shows indications of stretch. Secondly, the difference in the ID and OD of the core barrel (0.5 inches) and the larger diameter of the drill bit shoe caused core growth. If the formation being penetrated was loose, the extra material could be pushed into the walls of the borehole. Core growth would be minimal in this case. If the formation was dense and compacted, the material would tend to take the path of least resistance into the core rod. Once the core was laid out in the troughs, the visual logging process had to take the core growth percentage into account in order to reasonably place the material contact depths. The most reliable method for determining contact depths was by interpolating the percentage core growth over the drilled interval by measuring the recovered core length with a steel rule and determining a simple ratio of recovered core per core run. For example, if the observed core expansion was 50 percent, then a two-foot thick sand layer would be given a thickness of about 1.5 feet in the logs. Likewise, a five-foot thick silt bed would be given a relative thickness of 3.5 to 4 feet. Where a large percentage of the growth was clearly the result of extrusion stretch over specific intervals within the core run a greater percentage of the correction was applied to the stretched interval. The interpolation was done during logging and boring logs were generated considering the interpolated contact depths,.

Regardless of the percentage core growth, the relative errors in visual logging were limited to the actual length of the core run and errors were not cumulative, i.e. errors in contact depths would not carry over into the next run. It was strictly known what the top and bottom depth of each core run was. If, for example, a 10-foot core run covered depths from 160 to 170 feet, then the errors in contact depths only applied to that length of core. Core runs above and below this run would be unaffected by the core growth observed in the 160- to 170-foot run, since their respective starting and ending depths were fixed. The relative logging errors would be small in determining the exact depths of each stratigraphic contact. Core run lengths should be kept to a minimum to reduce error and maintain stratigraphic control.

Rind formation was another problem unique to rotary sonic drilling that required additional effort to overcome. The vibratory action of the method caused the finer grain material to migrate to the outside of the core. The rind can mask the lithology of sediments particularly when small percentages of coarse grain material are present in fine grain matrix. Although the rind problem is easily overcome by examination of the core interior, it does require that the core be cut open and examined. This does require additional time and requires additional diligence in the examination of core segments.

Borehole Geophysical Methods

The two exploratory borings (EXB-01 and EXB-02) were geophysically logged. Once these two holes were advanced to 250 feet, a three-inch diameter schedule 80 PVC pipe was inserted into the six-inch diameter borehole before the outer steel casing was removed. The geophysical suite was then run within the PVC casing. Geophysical logs used in EXB-1 and EXB-2 were induction (resistivity) and natural gamma (gamma ray) logs. The logs were run inside the PVC casing from total depth, approximately 250 feet, to ground surface. The borehole annulus was water filled below the water table and air filled above. The induction log was run with a 1.25 inch diameter DHT-1 induction tool with a detector spacing of 24 inches. The induction tool data was recorded as both conductivity and its reciprocal resistivity. The gamma ray log was run using a 1.69 inch diameter natural gamma tool with a 4 inch detector length at a logging speed of 24 feet/minute.

Geophysical logs are standard methods for lithology determination in petroleum and mining applications. Although application of geophysical logging in environmental application has a shorter history, recent experience has proven it to be a reliable lithological indicator. Borings EXB-01 and EXB-02 test cases compared the rotary sonic drilling method against geophysical methods, assuming that geophysics provided the best overall picture of the lithologic section. The following discussion uses the geophysical logs as a basis for comparison, but as is illustrated in this evaluation, geophysical logs also have inherent limitations that introduce additional uncertainty.

Geologic and Geophysical Logging Evaluation

The first two borings of the series (EXB-01 and EXB-02) tested the adequacy of rotary sonic drilling for use in the investigation. Comparisons between the geologic logs and interpreted geophysical logs were the basis for evaluation of the drilling method. Evaluations made for exploratory borings EXB-01 and EXB-2 indicated that the rotary sonic method provided sufficient accuracy to warrant it's application to the remaining stratigraphic borings. The following discussion provides a detailed evaluation of the first of the geologic and geophysical logging of the upper 140 feet of EXB-01. This interval provides a representative picture of the method of evaluation, the relative difference between the data sets, and the uncertainty involve in the comparison.

Bed resolution, contact displacement and characteristic response to lithologies are key issues in the interpretation of geophysical logs. Bed resolution is the ability of a geophysical tool to respond to thin beds or sharp contacts. Contact displacement is the vertical offset of the observed response to a contact. The accurate determination of the contact displacement is a key factor in the accurate interpretation of geophysical logs.

Characteristic response is the direction in which a geophysical log trace is deflected in the presence of a specific lithology. For example, the positive deflection of the natural gamma log in response to clay material is an expected characteristic response. Sand does not normally produce a strong deflection if the natural gamma tool. When a non-characteristic response is

encountered, as was found in this investigation, additional uncertainty is introduced. Bed resolution, contact displacement and characteristic response factors introduce uncertainty in the interpretation of geophysical logs. Determination of these factors in shallow fresh water terrestrial environments is much less certain than in traditional deep seated saline/fresh water petroleum environments. The fundamental question in the evaluation of the rotary sonic drilling is whether the method provides greater accuracy than geophysical logging methods.

Evaluation Methodology

Evaluation of the rotary sonic drilling method requires the examination of the geologic logs against a standard. The standards used in this case are geophysical logs. Geologic logs present detailed representations of the subsurface, but depositional trends are not easily perceived from detailed descriptions of lithology. Geophysical tools, on the other hand, respond to physical parameters that relate to lithology and depositional environment. The geophysical logs present data in a format that is easier to evaluate for trends and is less susceptible to human error. However, the interpretive nature of geophysical logs does introduce the human element into the comparison of the two methods. Contact depths are manually picked from the log traces, and as a result, the nature and depths of lithologies and contact depths are not absolute.

The geologic logs for exploratory boring (EXB-01) are examined in detail in the following paragraphs. Geophysical logs are the basis for comparison. As illustrated in the following discussion, geophysical logs have associated uncertainty. The comparison is made with the full realization that this is the case. The comparison is both qualitative and quantitative, with the examination of the ability of rotary sonic drilling to determine lithologic character and contact depths.

Exploratory Boring EXB-01 Evaluation

The geologic and geophysical logs for EXB-01 are depicted in Figures 3 and 4. Figure 3 represents the interval from ground surface to 70 foot below ground surface (bgs). The individual geophysical logs present characterizations of the interval that measure different physical properties. The resistivity profile presented by the induction log responds with an increase in measured values in the presence of coarse grained material (deflection to the right) and is an indicator of sand content. The natural gamma (gamma ray) log, responding to the presence of naturally occurring radioactive material (also with a signal increase), is normally considered to indicate clay content. However, at the Base the interpretation of these logs is complicated by the presence of coarse grained potassium feldspars. Potassium feldspars may contain radioactive potassium (40) which is detected by the natural gamma sensor. This factor represents a complication with respect to interpretation of the geophysical logs; adding information about the source areas of the sediments but also creating uncertainty in identifying the clay content of a given interval.

Upper Depositional Unit

The resistivity (induction) logs to a depth of 70 feet (Figure 3) are interpreted to show four distinct depositional cycles with associated lithologic variations. The depositional sequences include: three fining upward sequences (upper unit and units two and four) with transitional coarsening upward sequences near the top of each unit, and one predominantly coarse grain unit (unit three). The geologic log, derived from the rotary sonic core, sub-divides the upper 70 feet into thin beds of sand to silt lithologies. Bed thickness ranges from 0.5 feet to 8 feet, with most of the units ranging between two and five feet in thickness. These depositional sequences may represent three braided stream/fluvial environments (upper unit, units two and four) and a predominantly alluvial section in unit three.

The upper depositional unit (Figure 3) represents coarse grain surface sediments to about eight feet bgs, and an upward fining sequence to a depth of about 26 feet bgs. The upper eight feet of the log reflects the transition from desiccated near surface sands to a finer grain silt, sand and possibly clayey lithologies. The near surface resistivity response, approaching 100 ohm-meters, shows the influence of dry surface sediments and increasing moisture content to about five feet. The natural gamma response indicates decreasing sand content over the five to ten foot interval with a positive deflection of the geophysical log. The natural gamma response exhibits a positive response to a reading of 85 API units, that would normally represent increasing clay content thorough the seven to eleven foot interval. Increasing silt content is recorded on the geologic log between five and 11 feet with a silty sand classification of the material. The geophysical response apparently contradicts the geologic log interpretation. The geophysical and geologic log from the adjacent exploratory boring EXB-02 some 450 feet to the southwest (not shown) supports the presence of a clayey unit at this depth. The character of the geophysical response is similar to the that observed in EXB-01. The apparent misidentification of the clay unit points out the limitations of geologic logging of core and does not reflect on the rotary sonic method itself.

A fining upward sequence within the upper unit is interpreted from the resistivity log between ten and 26 feet (bgs), reaching a resistivity maximum at about 25 feet (32 ohm-meters). The natural gamma response support the resistivity interpretation with a nearly flat value of approximately 45 API units. Geologic logging reflects a similiar sequence with a silty sand unit between eleven and seventeen feet (bgs), with a contact at seventeen feet to a silty sand. The depositional cycle is terminated at twenty five feet (bgs) with a decrease in grain size and a contact with a clayey sandy silt unit. The transition into the next depositional sequence (unit two) is indicated by a decrease in resistivity below 25 feet (bgs) and a positive deflection in the natural gamma response starting at 26 feet. Interpretation of the geophysical logs places the contact at 26 feet. The geologic logs places the contact at 25 feet (bgs) representing a one foot difference in the contact interpretation. The origin of this uncertainty is unclear and could originate in drilling or in interpretation of the geophysical logs but a one foot disagreement of contact depth is observed between the two methods. This uncertainty is well within acceptable limits for the objectives of the investigation.

Depositional Unit Number Two

A depositional unit similiar to the overlying unit is present between 26 and 46 foot depths, although distinct characteristics indicate separate source areas for the sediments. Geophysical logs over this interval illustrate the weakness in the geophysical tools for lithologic interpretation without supporting geologic information from core. The high proportion of naturally radioactive sediments are apparently overprinting the signature of the natural gamma log giving the appearance of higher clay contents than are actually present in the coarse grain sediments. The rotary sonic core provides the data necessary to distinguish otherwise contradictory indicators from the geophysical tools. The geologic log illustrates a sequence similiar to the overlying strata with alternating silty sandy to sand layers from two to five feet thick. Clay content is higher with a minor clay component in the top bed (25 feet bgs) and a two foot clayey silt layer at 28 feet (bgs). The basal lithology for the unit is a thin (1 foot) clay layer at 45 feet (bgs).

The resistivity response over the 26-35 foot interval (Figure 1) indicates fine grain sediments with values 15 and 20 ohm-meters. Silty sand layers at 28 and 32 feet in the geologic log are not readily apparent in the resistivity log. The remainder of the interval (33 to 43.5 ft. bgs) is interpreted from the resistivity response to have increasing sand content, with maximum sand at 42 feet (40 ohm-meter resistivity value). The base of the interval is placed at 43.5 feet (bgs) where a 20 ohm-meter decrease in resistivity response indicates the presence of the basal clay. The basal (45 foot bgs) clay layer is displaced 1.5 feet shallower on the resistivity log than on the geologic log. The resistivity log contact depth of the basal clay is within 1.5 feet of the

contact determined by the sonic drilling method.

The resistivity interpretation appears straight forward enough and is generally in agreement with the geologic log, but examination of the natural gamma logs shows only partial agreement with the resistivity interpretation. The four distinct sand-silt-clay layers in the geologic log (25 to 35 feet bgs) appear in the natural gamma log as a gradational sequence with maximum clay content at 30 feet (bgs). This maximum clay content is represented by the 70 API unit peak in the gamma log at 30 feet (bgs). The difference between the two interpretations, gradational verses abrupt contact, is subtle and presents only a slight modification of the lithologic picture.

The importance of accurate geologic logs supplied by the rotary sonic method is illustrated in the lower section of this depositional interval. The natural gamma log for the 35 to 45 foot interval contradicts the resistivity interpretation when evaluated using the normal criteria equating gamma response to clay content. Natural gamma log over this interval indicates clay lithology with a distinct positive response, up to 130 API units, over the entire depth interval. Sand content is also apparently increasing over the interval as indicated by increasing resistivity. The gamma and resistivity responses, in the absence of other data would indicate a mixture of sand and clay. Detailed core obtained from the rotary sonic drilling provided a much different interpretation. The three lithologic units logged from the core were sandy silt to sand. No clay was indicated in the log. The lithologies were grayish brown to light brown indicating the possible presence of potassium feldspars. Potassium feldspar sands could cause the response observed in both the geophysical logs. The final interpretation of the interval lithology is a sand to silty sand possibly from Sierra Nevada Mountains granitic sources to the east. The hydrologic significance of the sand-clay verses the silt-sand lithology is considerable. The availability of core provided by the sonic drilling provided the mechanism for the accurate interpretation of this interval.

Depositional Unit Number Three

A depositional unit dissimilar from the others observed in the upper 70 feet of the section (Figure 3) is present between 46 and 56 feet (bgs). This cycle exhibits a coarsening upward rather than fining upward trend. The geologic log indicates light olive gray color sand to silty sand. The resistivity is clearly in agreement with a 40 ohm-meter reading at 47 feet (bgs) and a general decrease in resistivity to about 20 ohm-meters at 55 feet. The base of the unit on the geologic log is 56 feet (bgs) but is interpreted at 54 feet on the geophysical log. A difference of positive two feet is seen at this contact.

Two physical properties that distinguish depositional unit number three from the units above and below it are natural gamma response and color. The unit exhibits low natural gamma values and much darker colors. The natural gamma response is more typical of what is expected of coarse grain lithologies. These characteristics indicate a different source area for the sediments, possibly from non-granitic source rocks to the west.

Depositional Unit Number Four

The character of depositional unit four, between 56 and 76 feet (bgs) returns again to patterns seen in the upper unit and unit two depositional sequences. The unit consists of fine grain silt to silty clay sediments at a 56 foot depth (Figure 3), with a transition to coarse grain material at the base between 70 and 76 foot depths (Figure 4). The geologic and the geophysical logs indicate a transition to thicker layers and less intermixing of different grain sizes within the layers.

The resistivity log shows a gradual increase in grain size throughout the interval with an exception over the 66 to 70 foot depths, where a decrease in resistivity values responds to a clayey silt layer seen on the geologic log (Figure 3). A large resistivity increase corresponds to

the presence of sand between 70 and 76 feet on the geologic log. The natural gamma response, although generally high over the whole interval, appears to respond to this clayey silt layer. The geophysical response of the clayey silt and the sand layer both appear to be shifted about two feet (deeper) than the geologic log.

Depositional unit four shows similarities to the upper two units of the section although the layers are thicker and show less mixing of coarse and fine grain material. The high natural gamma response over the interval indicates either an undetected clay component over most of the interval or shows influences from natural radioactivity from a granitic sediment source areas.

Depositional Units Number Five, Six and Seven

The depositional environment changes below 76 feet in the section with a change from gradually fining upward units to a repetition of silty lithologies overlying fairly well developed sand layers. The abruptness of the contacts between the silt and sand units is sharper and the gradation from sand to silt lithologies is less distinct in these depositional units. Hydrologicly, the environment changes to a water table present below 80 feet (bgs) and a change from unsaturated to saturated conditions. The response of the resistivity log is not as distinct as might be expected for a change in saturation. The use of geophysical methods in combination with rotary sonic core provides the data necessary to cross check the geologic log and to refine contact depths.

Depositional units five, six and seven are 19 feet, 10 and 15 feet thick respectively (Figure 4). The upper portions of all three layer consist of silt-clay mixtures with various percentages of sand at various levels. The base of each interval includes a three to four foot thick well developed sand layer. Some disagreement is evident between the geologic and geophysical logs with respect to the placement of the basal sand unit in unit seven. These layers are very important from a hydrologic standpoint and are potential target zones for monitoring wells.

Depositional unit five is defined on the geologic log (Figure 4) as extending from 76 feet to 95 feet (bgs). The contact determined on the resistivity log is about two and one-half feet higher at 93.5 feet (bgs). The geologic log shows a sequence of clayey silt, sandy silt and four foot thick clean sand forming the basal lithology. The resistivity log reflects the character described in the geologic log although a higher resistivity near the top of the interval indicates the presence of more coarse grained material than described in the log. The natural gamma log shows decreasing values assumed to represent decreasing clay content down to about 88 feet (bgs). The increase in natural gamma response below 88 feet is attributed to coarse, potassium feldspar rich, sediments of possible Sierra Nevada origin. The increase in gamma log response is also coincident with a change in sediment color from light olive gray to moderate brown, also indicating different sediment source areas. The base of the unit on the geologic logs is determined to be about two feet deeper than the resistivity log contact.

Depositional unit six shows a strong resemblance to unit five except that it is thinner, approximately ten feet total thickness, and has a lower resistivity indicating less sand content. Unit six's upper contact is placed at 95 feet (bgs) on the geologic log and it's lower unit is interpreted at 105 bgs. The contacts interpreted from the resistivity are slightly different at 94 feet and 104 feet (bgs). The natural gamma log does not show increase through the sand interval. The low gamma log response and the light olive gray color support a possible non-Sierra Nevada origin for the sediments or may represent the erosion of non-granitic sediments adjacent to the Sierra Nevada range. The various methods strongly support each other in the interpretation of this interval.

Depositional unit seven, in contrast to unit six, provides interpretations that do not strongly support each other. Unit seven is defined on the geologic log between 105 feet and 120 feet

(bgs) with two separate three foot sand layers separated by a sandy silt and hardpan layer. The resistivity and natural gamma responses both support the presence of a single sand layer from about 114 feet to 119 feet (bgs). The mutually supporting evidence provided by the two geophysical methods suggests that a single sand unit interpretation is most likely to be correct. Determination of the lower contact of this unit is subject to question as a result of the above stated disagreement between the sonic core and the geophysical methods. The resistivity interpretation places the contact at 119 feet (bgs).

Depositional Unit Eight

Depositional unit eight is the lowest unit seen on Figure 4, extending between 120 and 140 feet (bgs) on the geologic log. The unit reflects a change to a predominantly sand lithology. The geologic and resistivity log are in agreement with a silt component seen near the top of the interval giving way to high resistivity sand below 130 feet. The top of the depositional unit as depicted on the geologic log falls to within about two feet of the top picked by the resistivity response. The positive response of the natural gamma log indicates a possible Sierra Nevada granitic source terrain for the sediments although its color is darker than other units suspected of having similiar origins.

The geologic interpretation of the section described above is of a depositional environment that was initially very high energy with the deposition of a thick sand sequence represented by unit seven (Figure 4). A fluvial or distal alluvial environment is interpreted for units seven through five. The environment appeared to be stable for relatively long periods of time allowing the deposition of slightly thicker more lithologicly distinct units. This may represent a period of glacial influence. The upper unit, unit two and unit four apparently represent more of a braided stream/ alluvial environment with more continuous change of grain size and more gradational contacts. Unit three possibly represents a sheet flow alluvial outwash deposits over a relatively short interval. Source areas for the sediments vary, with influences of the granitic Sierra Nevada mountain ranges apparently alternating with either California Coast Range sources or reflecting the erosion of sediments overlying the Sierra granitic.

Method Evaluation

Comparisons between sonic core and the interpretation of geophysical logs for the lower sections of EXB-01 and the second exploratory boring, EXB-02, yielded similiar results to those described above. The limitations of coring, geologic logging and geophysical logging methods all contribute uncertainty to the process. The rotary sonic method was determined to adequate for use in stratigraphic drilling and the remaining three stratigraphic borings, EXB-03 through EXB-05 were completed.

Conclusions and Application

The preceding comparison between rotary sonic core drilling and borehole geophysical methods provided a basis for the evaluation of the drilling method for use in stratigraphic borings. The upper 140 foot interval of exploratory boring EXB-01, drilled at the Fresno Air National Guard Base, illustrates the strengths and weaknesses of geologic and geophysical logging, and rotary sonic drilling. Geologic logging provides good visual representations of the geologic section, is subject to human error and time constraints inherent to drilling operations. Geophysical logging, although less susceptible to error, is still interpretive and is subject to associated uncertainty. Geophysical logging provides a good unbiased measurement of the subsurface, but measures only physical properties and is subject to misinterpretation, if the interpreters assumptions are not valid. Rotary sonic drilling provides very good core recovery and site lithology can be logged using the method. Lithologic description from rotary sonic core is subject to the same limitations as geologic logging, human error. The determination of lithology contact depths is complicated

by core growth and extrusion stretch, although measurement and interpolation partially correct for this phenomena.

Rotary sonic drilling is a reliable method with which to characterize the hydrogeologic regime and contaminant distribution beneath the Base. The reliability of the drilling method was evaluated by geophysically logging the boreholes and comparison with the results of visual logging of the rotary sonic core. Core growth appears to be some what systematic with respect to lithology, with sand units showing the least and silts the greatest tendency for growth. The core growth can be compensated for when the relative ratio of core growth to run interval is considered along with the systematic effects of lithology. The comparison of rotary sonic and geophysical logging indicates that lithologic contacts can be determined to within a couple of feet. The comparison indicated that the rotary sonic method provided lithologic information of sufficient accuracy for use in the desired application.

The site investigation at the Fresno Air National Guard Base in Fresno, California was completed using rotary sonic drilling. Monitoring well installation was accomplished based on the stratigraphic information derived from rotary sonic drilling. The comparison of the geologic logs derived from the rotary sonic method and the results of the geophysical logs strongly suggest that the use of both techniques provides additional certainty in the determination of site lithologies and in the placement of monitoring wells required for investigations.

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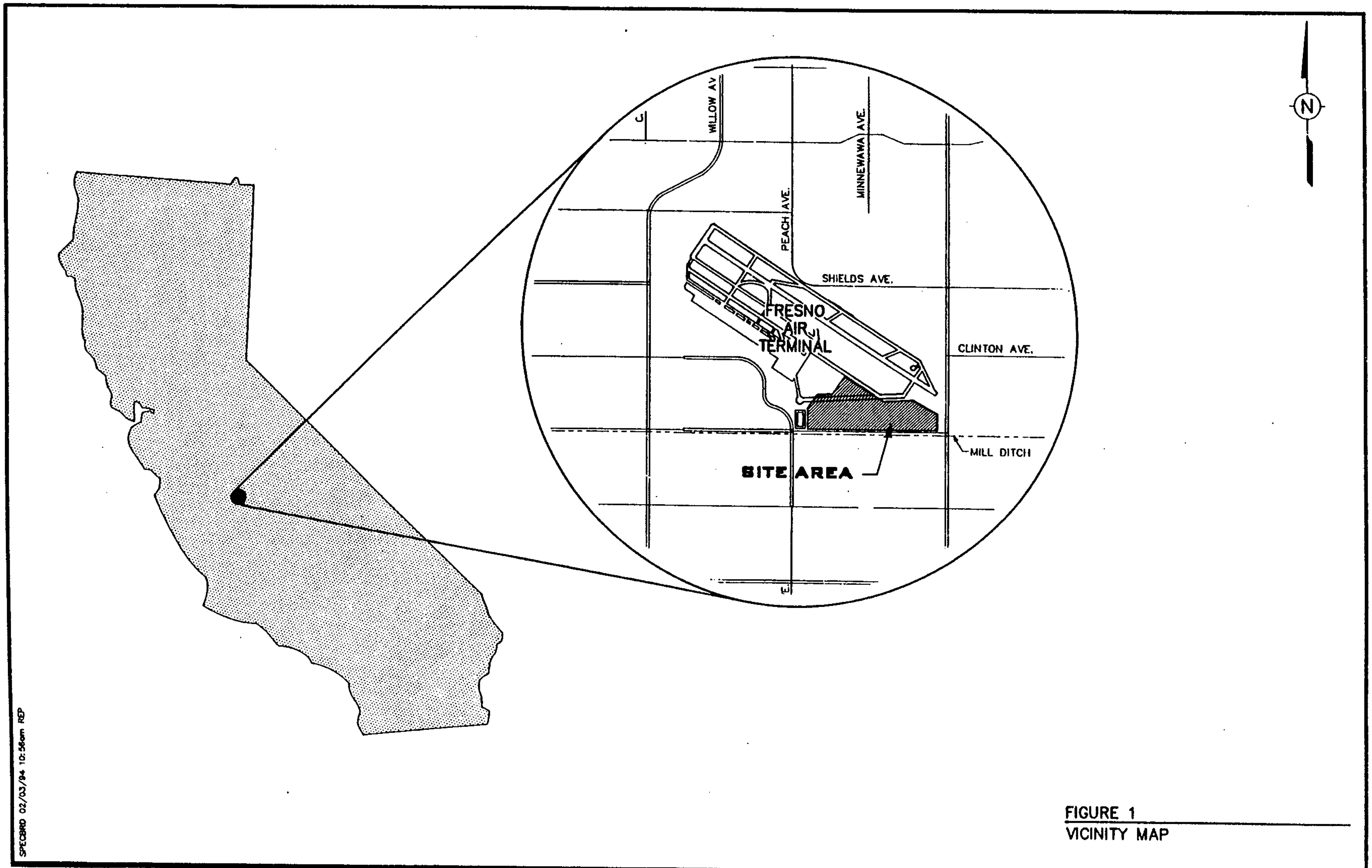


FIGURE 1
VICINITY MAP

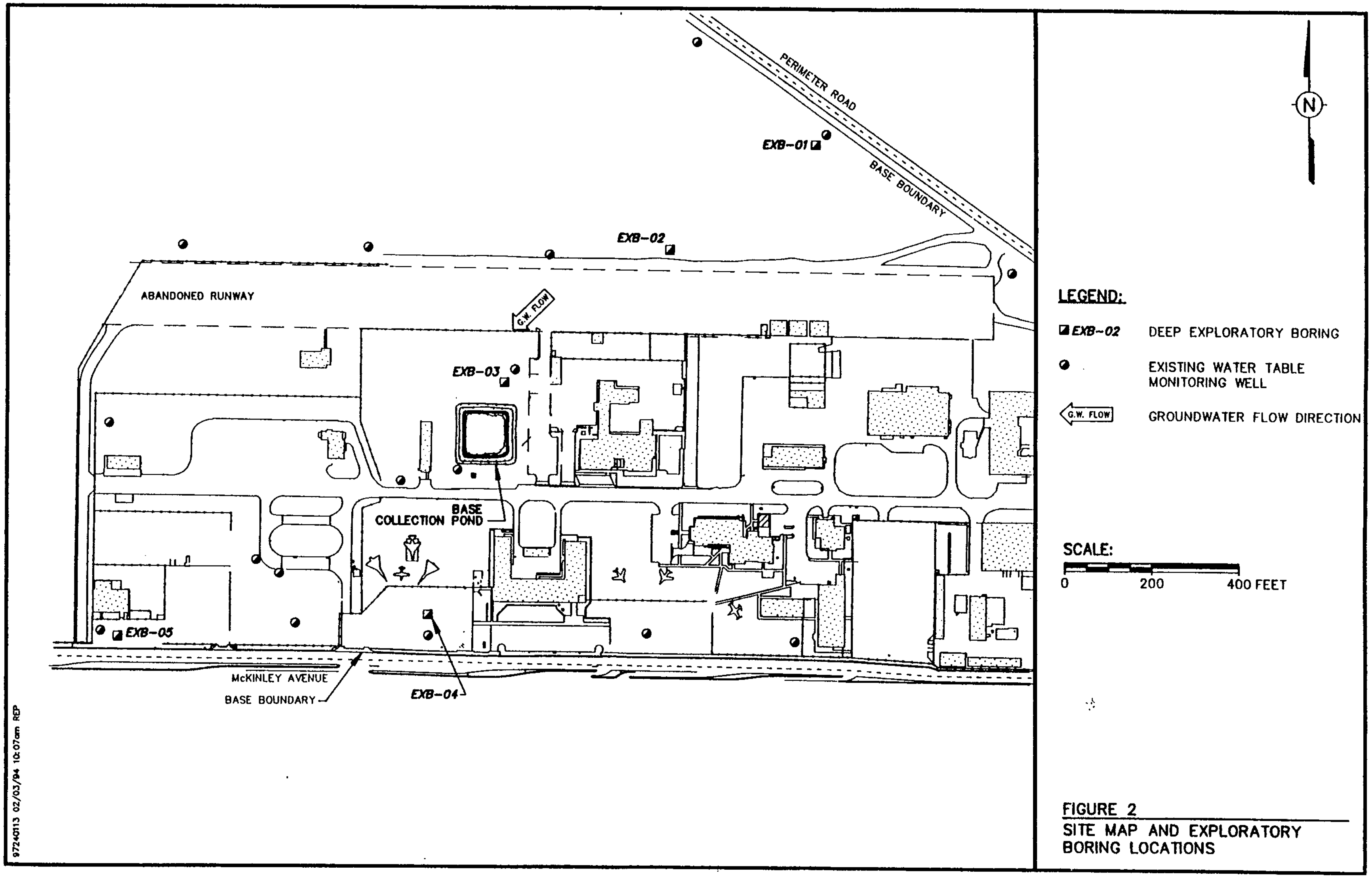
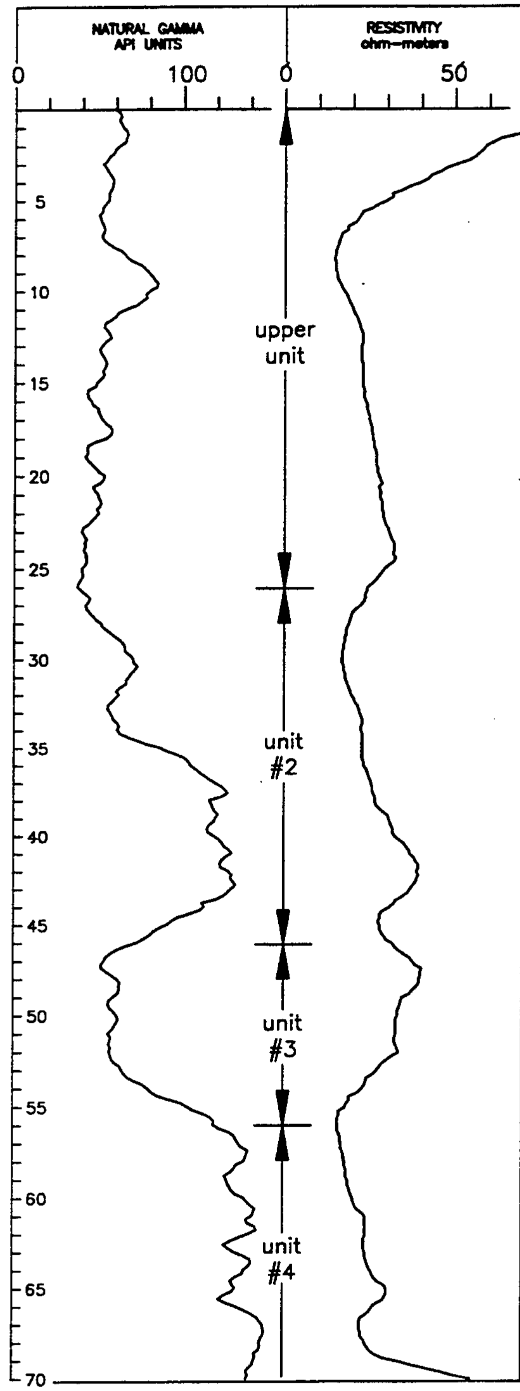


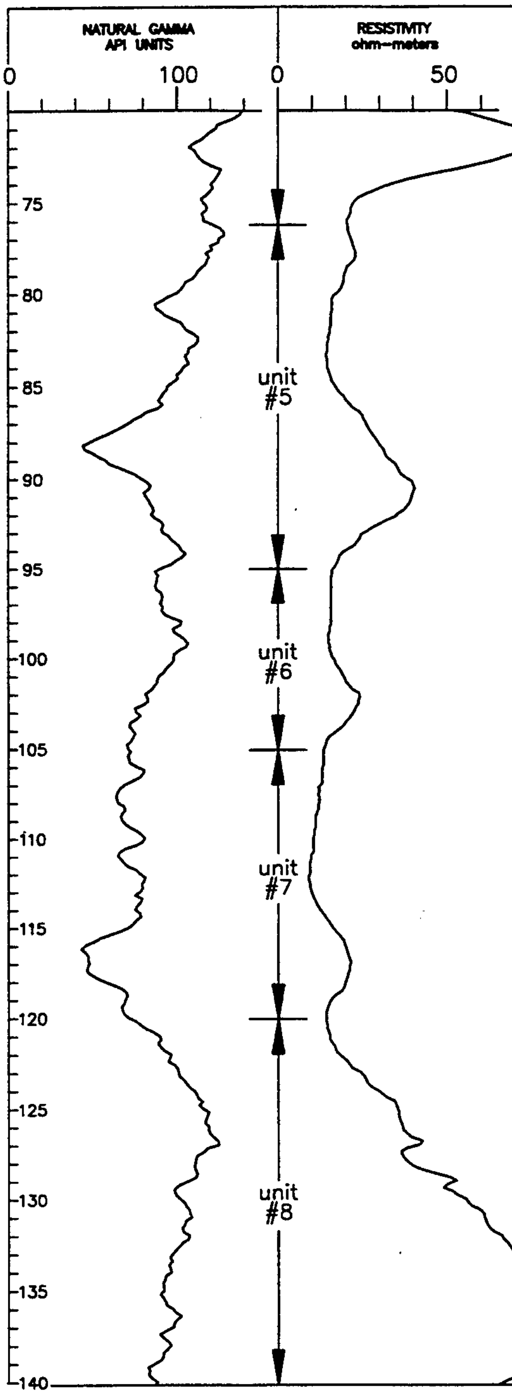
FIGURE 2
SITE MAP AND EXPLORATORY BORING LOCATIONS



USCS	DESCRIPTION	Depth
sm	SAND WITH SILT; gray orange; very soft; <10% silt; dry.	2.0'
sp	SAND; dark yellow brown; medium sand, moist, silt <10%, moist, slightly.	5.0'
sm	SILTY SAND; minor clay; dark brown; slightly moist; hard; medium sand; silt to 30%.	8.0'
sm	SILTY SAND; grayish red; hard light olive gray; slightly moist.	11.0'
ml	SANDY SILT; moderate yellow brown; firm; nonplastic; slightly moist. Slightly plastic at 15 ft. Some clay at 15 ft.	17.0'
sm	SILTY SAND; moderate brown; firm; silt 30%; moist; micaceous; medium sand. Firm, but platy chunks, coarse sand at 20 ft. with 40% silt; firm; fine sand. Some clay. Silt 20% at 25 ft. Medium sand.	25.0'
ml	CLAYEY SANDY SILT; olive gray; fine sand; moist; very slight plasticity.	28.0'
sm	SILTY SAND; moderate brown; 40% silt; non-plastic; fine to very fine sand.	30.0'
ml	CLAYEY SILT; moderate red brown; moist; slightly plastic; very fine sand; <5% firm.	32.0'
sm	SILTY SAND; moderate yellow brown; hard; medium sand; silt 20–30%; moist.	35.0'
ml	SANDY SILT; grayish brown; moist; hard; nonplastic; fine sand <10%; light brown at 37 ft.; some gray mottle; very fine sand at 38 ft.	39.0'
sm	SILTY SAND; light brown; stiff; silt 20%; sand medium to coarser; slightly moist; minor very coarse sand.	39.5'
sw	SAND; light brown to moderate yellow brown; very coarse sand; clean at 40 ft.; soft; silt 30% at 41 ft.; <5% below; some fine gravel <<1%.	45.5'
cl	SILTY CLAY; light olive gray; soft; medium plasticity; moist; pred mottle.	46.5'
sm	SILTY SAND; light olive gray with light brown streaks; fine sand; silt 35%; medium hard; slightly moist; <5% silt at 48 ft.; medium sand at 48 ft.; medium yellow brown at 48 ft.; sand coarse at 50 ft.; silt >40% at 51 ft.	51.5'
sp	SAND; light olive gray to pale yellow brown; medium sand; slightly moist; poorly graded; some silt; generally <5%; some thin layers >15%; increasing silt with depth to 40% at base.	56.0'
ml	SILT; moderate yellow brown with pale olive mottle; hard to very hard; slightly moist; non-plastic.	57.0'
cl	SILTY CLAY; moderately brown; moist; hard; medium plastic; minimum or very fine sand <1%.	57.5'
ml	SILT; pale yellow; slightly moist; soft; light brown mottle. very fine sand <1%. Yellowish gray at 61 ft.; very slightly plastic; minor clay <1%; non plastic below 63 ft.	64.0'
ml	CLAYEY SILT; pale yellow brown; moist; plastic to slightly plastic; soft but crumbly. Pale olive at 68 ft.	70.0'

FIGURE 3
EXPLORATORY BORING EXB-01

EXB1-A



USCS	DESCRIPTION	Depth
		70.0'
sp	SAND; grayish orange; slightly moist; medium sand; slightly coarser below 72 ft.; poorly graded; subangular to angular grains.	76.0'
ml	CLAYEY SILT; light olive gray; moist; slightly plastic, mottled with dark yellow-orange; firm.	86.0'
ml	SANDY SILT; light olive gray; wet; medium sand 30%; non plastic; soft.	91.0'
sp	SAND; moderate brown; very soft; poorly sorted coarse sand; clean sand; wet.	95.0'
ml	SANDY SILT; light olive gray; slightly plastic; very moist; medium-fine sand 10%; some clay; soft.	98.0'
cl	CLAYEY SILT; pale yellow brown; moist to wet; plastic; soft; crumbly below 98 ft.	102.0'
sp	SAND; light olive gray; wet; medium sand; micaceous; soft.	105.0'
ml	SANDY SILT; moderate yellow brown; moist; firm; slightly plastic.	106.0'
cl	CLAY SILTY; light brown; moist; plastic; firm.	107.0'
ml	SANDY SILT; medium yellow brown; soft; wet; medium sand 15%; slightly plastic; moist.	110.0'
sp	SAND; light olive gray; wet; fine sand; very soft.	113.0'
ml	SILT WITH SAND; moderate yellow brown; moist; slightly plastic; soft; some clay content; fine sands <10%. Decrease in plasticity.	117.0'
	Hard pan; light gray; very hard; cemented clay.	
sm	SAND WITH SILT; light brown; very moist; silt 10-20%; fine sand; firm.	120.0'
ml	SILT; light brown; moist; non-plastic; sand 10%; fine to medium; very hard. Soft at base.	123.0'
sm	SILTY SAND; moderate yellow brown; very moist; silt up to 40%; very slight plasticity; soft.	128.0'
sm	SILTY SAND; moderate yellow brown; wet; very soft; decreasing silt content to contact; fine sand; silt content 5-10% at top of unit.	131.0'
sw	SAND; pale olive; very wet; very soft; coarse sand at top; minor silt at at top; decrease with depth. Very clean sand-very coarse at 135 ft.	140.0'

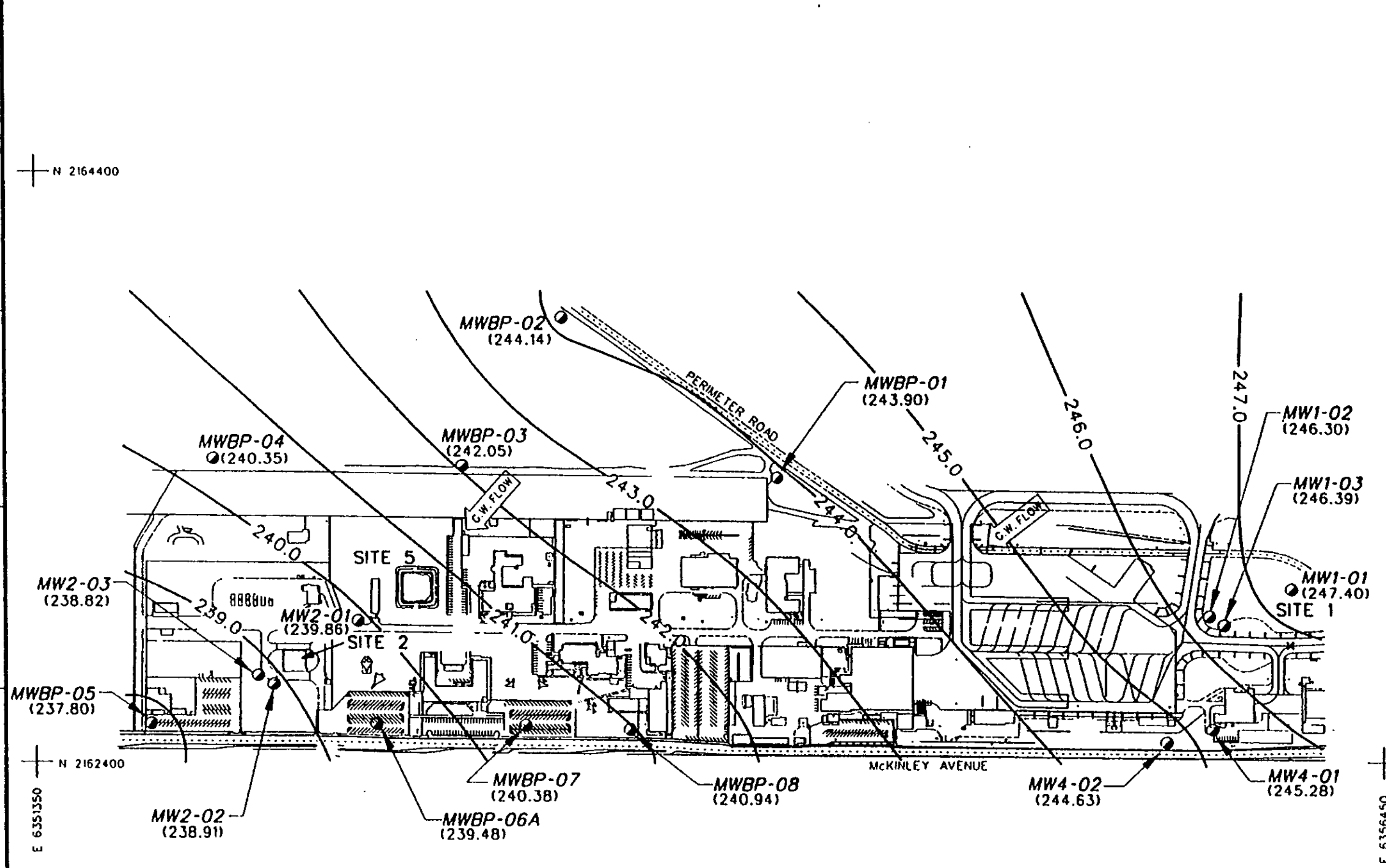
FIGURE 4
EXPLORATORY BORING EXB-01

EXB1-B

Acknowledgements
Investigation activities were conducted by IT Corporation under contract to the Department of Energy under Hazardous Waste Remedial Actions Program (HAZWRAP), under General Order Number 91B-99886C, Work Release No. K-08, for the Air National Guard Readiness Center (ANGRC) at the Fresno Air National Guard (ANG) Base. The authors wish to thank the ANGRC, specifically Mr. Mike Frey, project manager, and Mr. Russ Dyer, technical consultant, for their concerted efforts and willingness to expand the use of rotary sonic drilling technology in the environmental industry. Additional thanks are extended to HAZWRAP project manager, Mr. Dwight Robertson, for his diligence in obtaining acceptance for applying sonic technology to this investigation. Special recognition of ANG Base personnel, Lt. Colonel James Arthur and Major Gary Goorigian, is given for their assistance and cooperation during the field effort. Their roles in coordinating field demonstrations was key in the regulatory community's acceptance of the sonic drilling technology.

APPENDIX E

GROUNDWATER CONTOUR MAPS



LEGEND:

MW2-01 (239.86)	MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (ft. MSL)
244.0	GROUNDWATER ELEVATION CONTOUR
G.W. FLOW	GROUNDWATER FLOW DIRECTION

CONTOUR INTERVAL = 1.0 FT.

SCALE:

0 400 800FEET

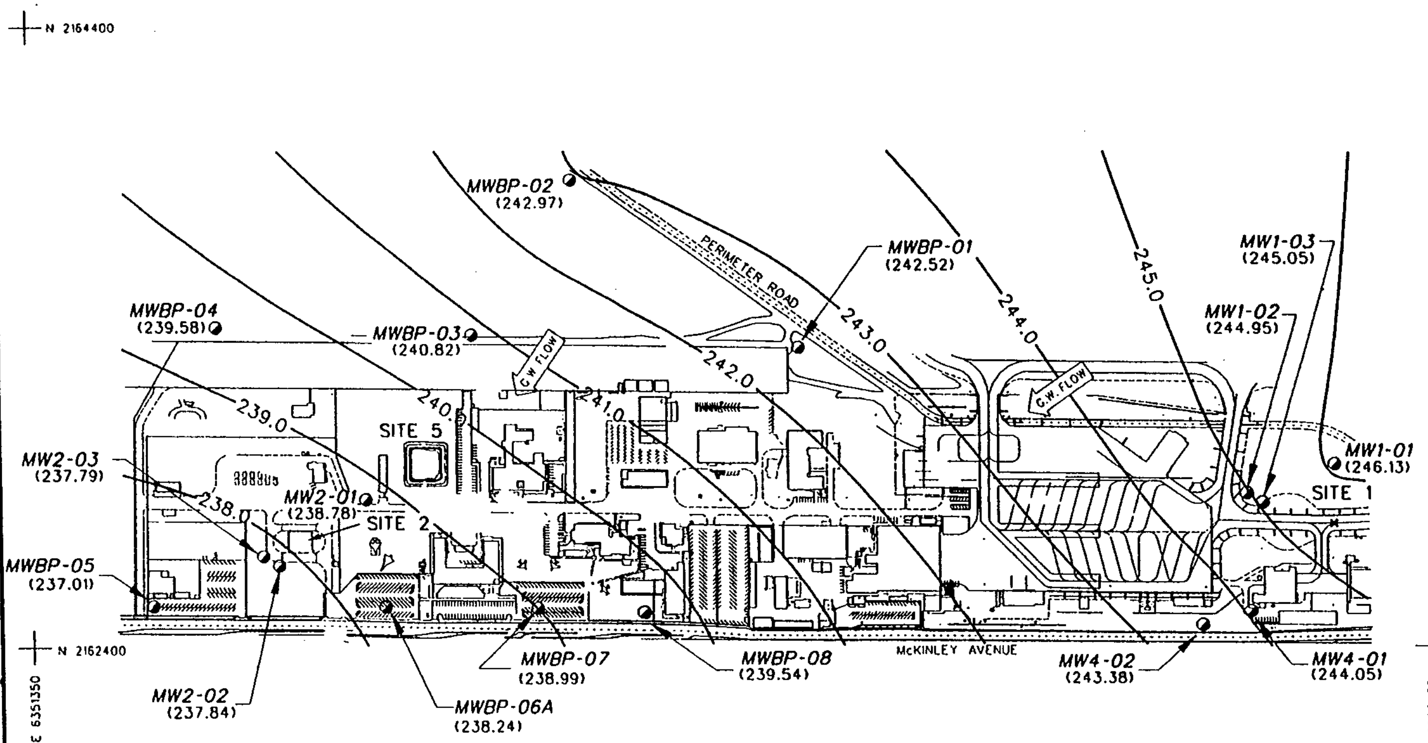
FIGURE E-1
GROUNDWATER ELEVATION CONTOURS FOR WATER TABLE WELLS, NOVEMBER 1990

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

IT INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/16/94	DATE LAST REV.:	DRAFT. CHCK. BY: CTUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.021
DRAWN BY: P. TERRY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

409724ES.021 16:16:09 Apr. 3, 1996 KHB



LEGEND:

MW2-01 (238.78) — MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (ft. MSL)

244.0 — GROUNDWATER ELEVATION CONTOUR

G.W. FLOW — GROUNDWATER FLOW DIRECTION

CONTOUR INTERVAL = 1.0 FT.

SCALE:

0 400 800FEET

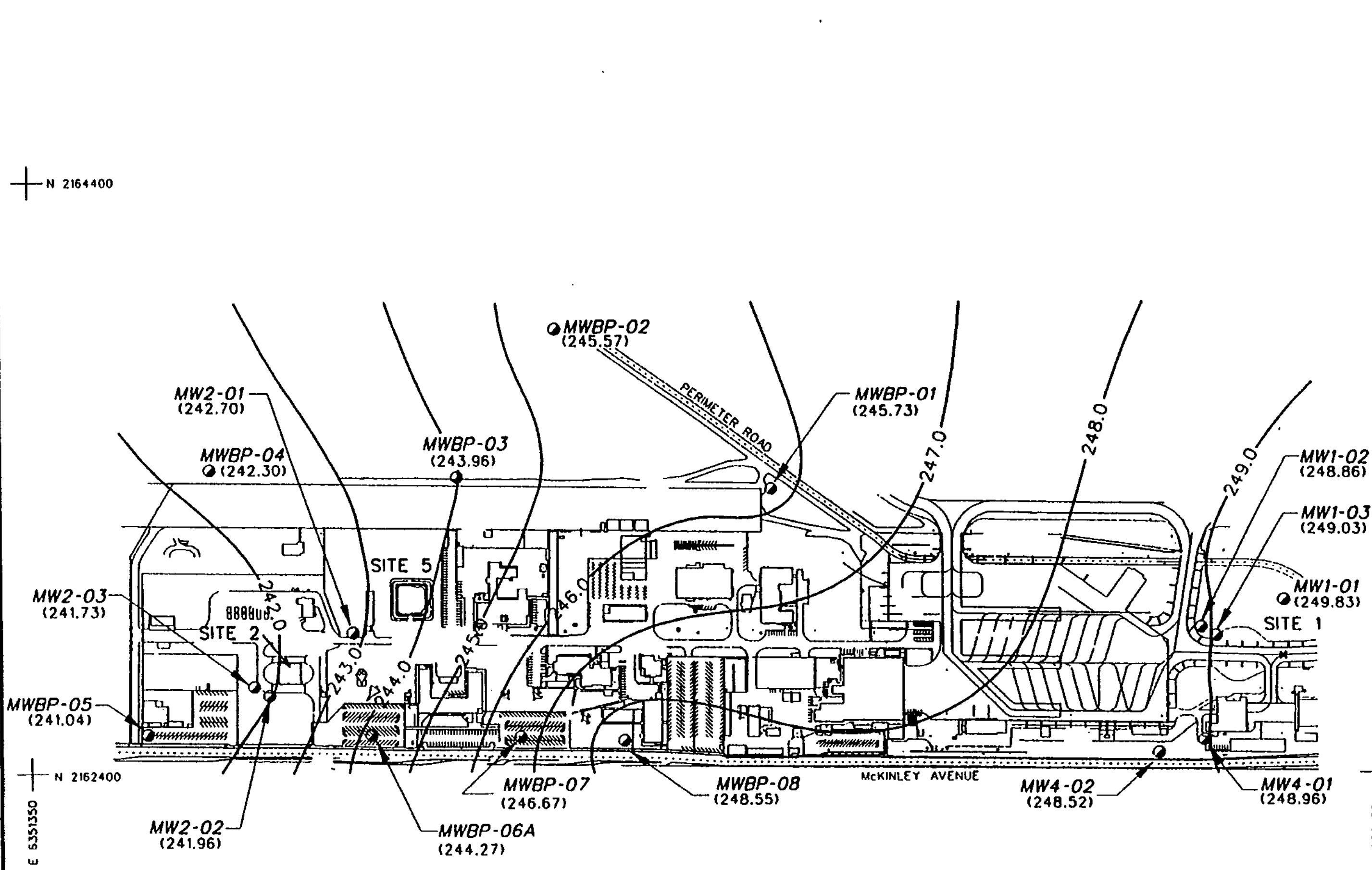
FIGURE E-2
GROUNDWATER ELEVATION CONTOURS FOR WATER TABLE WELLS, JANUARY 1992

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/16/94	DATE LAST REV.:	DRAFT. CHCK. BY: CTUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.022
DRAWN BY: P. TERRY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

409724ES.022 16:19 Apr. 3, 1996 KHB



LEGEND:

MW2-01 (242.70)	MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (ft. MSL)
—244.0—	GROUNDWATER ELEVATION CONTOUR

CONTOUR INTERVAL - 1.0 FT.

SCALE: 0 400 800FEET

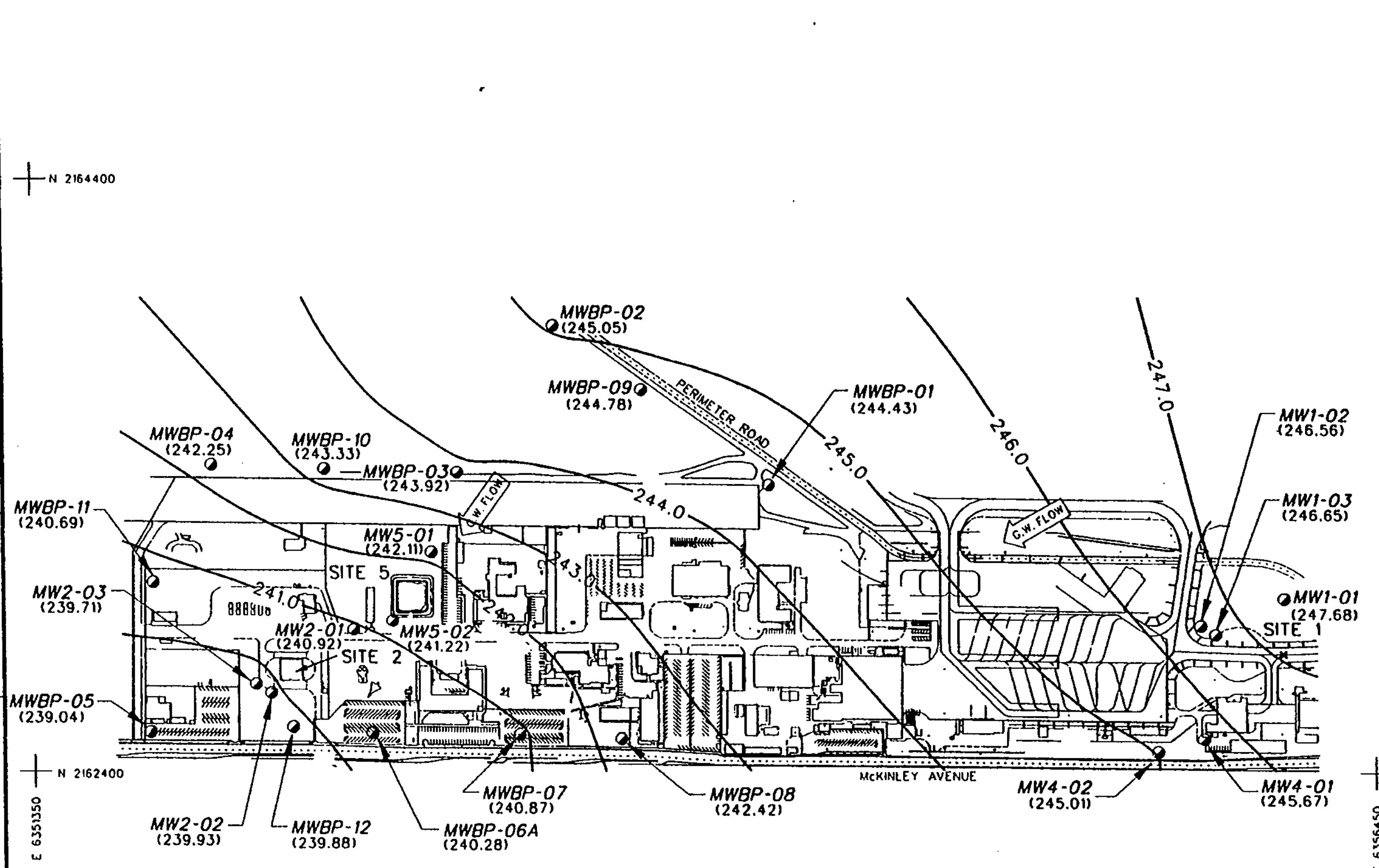
FIGURE E-3
GROUNDWATER ELEVATION CONTOURS FOR WATER TABLE WELLS, JUNE 1992

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

IT INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/16/94	DATE LAST REV.:	DRAFT. CHCK. BY: CTUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.023
DRAWN BY: P. TERRY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.:409724

409724ES.023 16:22:23 Apr. 3, 1996 KHB



LEGEND:

- MW2-01 (240.92) — MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (ft. MSL)
- 244.0 — GROUNDWATER ELEVATION CONTOUR
- G.W. FLOW — GROUNDWATER FLOW DIRECTION

CONTOUR INTERVAL - 1.0 FT.

SCALE: 0 400 800FEET

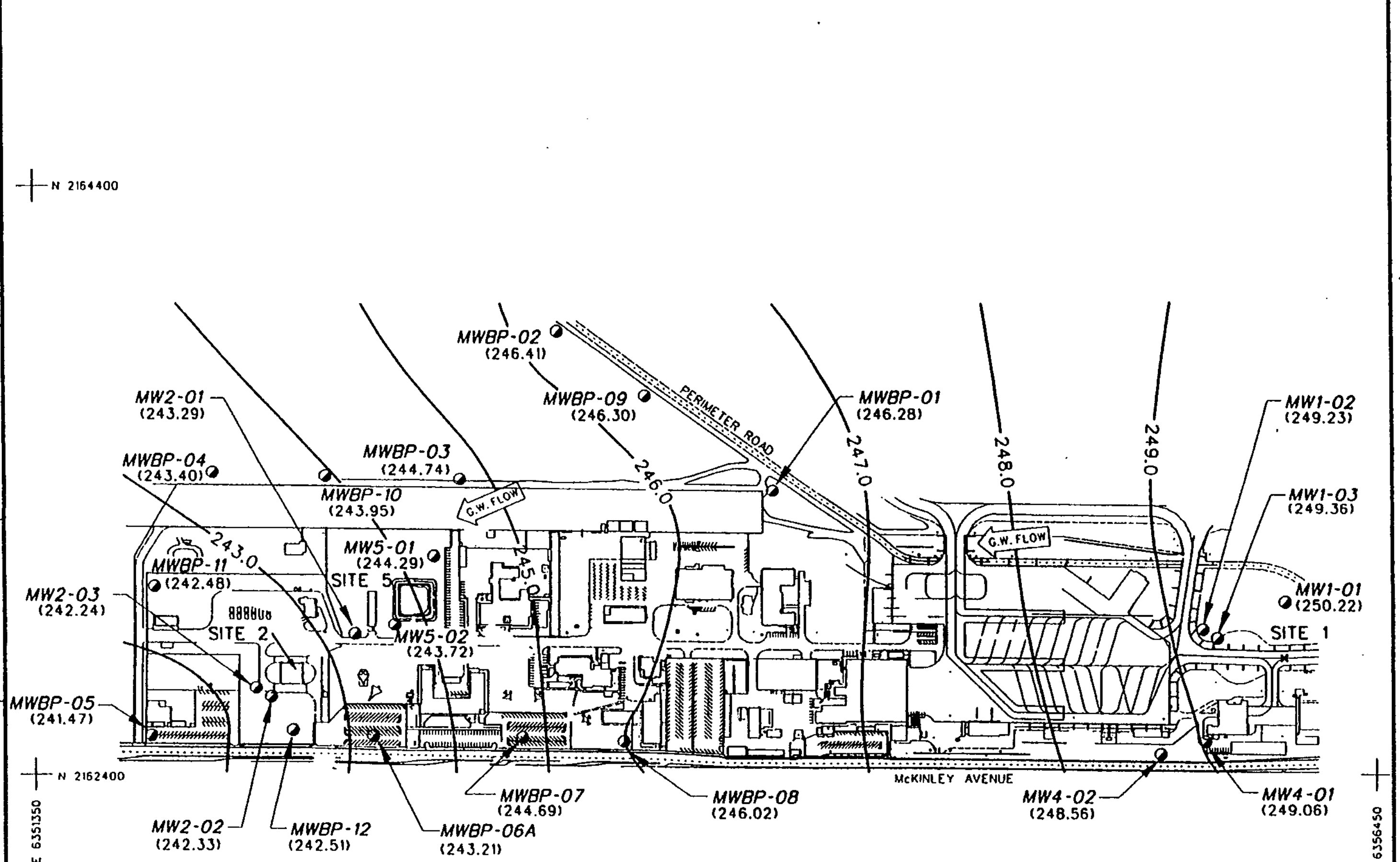
FIGURE E-4
GROUNDWATER ELEVATION CONTOURS FOR WATER TABLE WELLS, DECEMBER 1992

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

IT INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/16/94	DATE LAST REV.:	DRAFT. CHCK. BY: CTUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.024
DRAWN BY: P. TERRY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

409724ES.024 16:25 Apr. 3, 1996 KHB



LEGEND:

MW2-01 (243.29)	MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (ft. MSL)
244.0	GROUNDWATER ELEVATION CONTOUR
G.W. FLOW	GROUNDWATER FLOW DIRECTION

CONTOUR INTERVAL = 1.0 FT.

SCALE: 0 400 800FEET

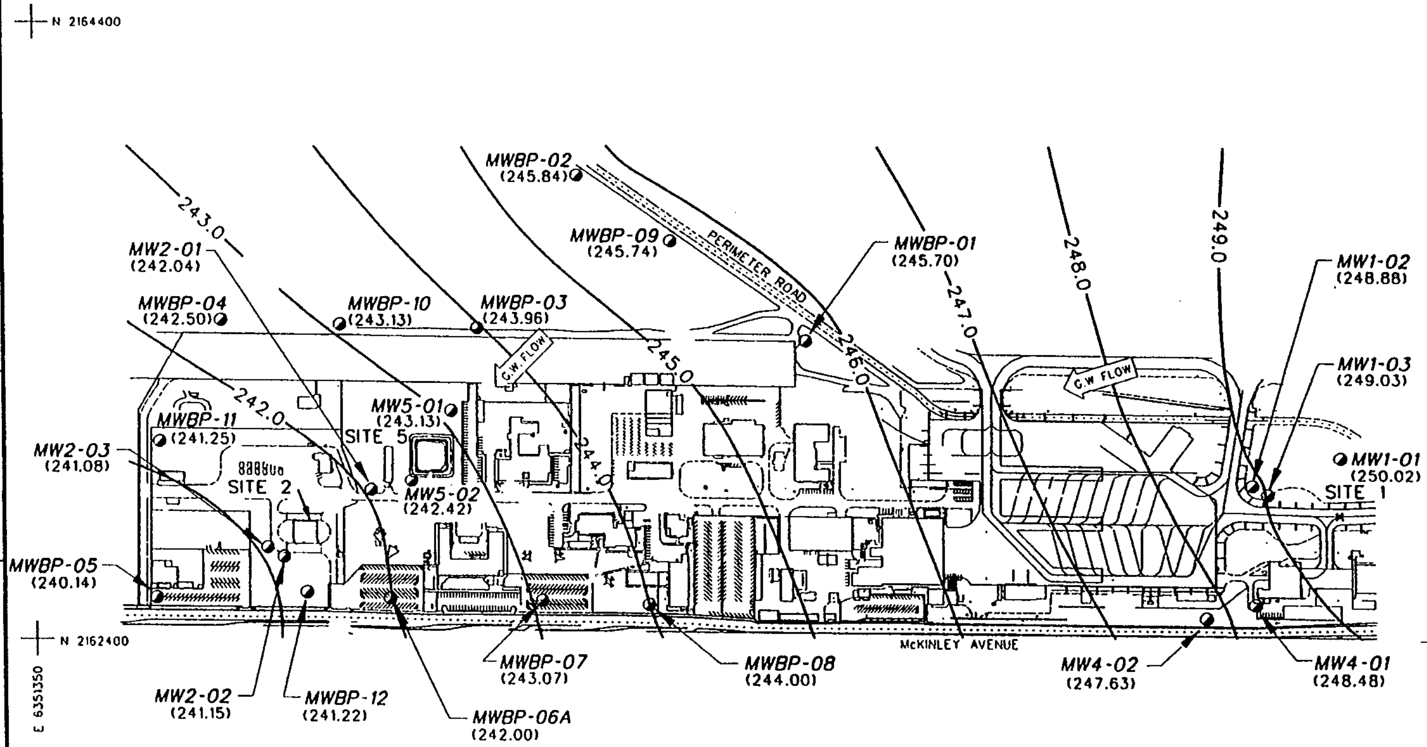
FIGURE E-5
GROUNDWATER ELEVATION CONTOURS FOR WATER TABLE WELLS, APRIL 1993

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/16/94	DATE LAST REV.:	DRAFT. CHCK. BY: CTUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.025
DRAWN BY: P. TERRY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.:409724

409724ES.025 16:30 Apr. 3, 1996 KHB



LEGEND:

MW2-01 (242.04)	MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (ft. MSL)
—244.0—	GROUNDWATER ELEVATION CONTOUR
G.W. FLOW	GROUNDWATER FLOW DIRECTION

CONTOUR INTERVAL • 1.0 FT.

NOTES:

1. "B" AND "C" SERIES WELLS ARE NOT SHOWN.

SCALE:

0 400 800FEET

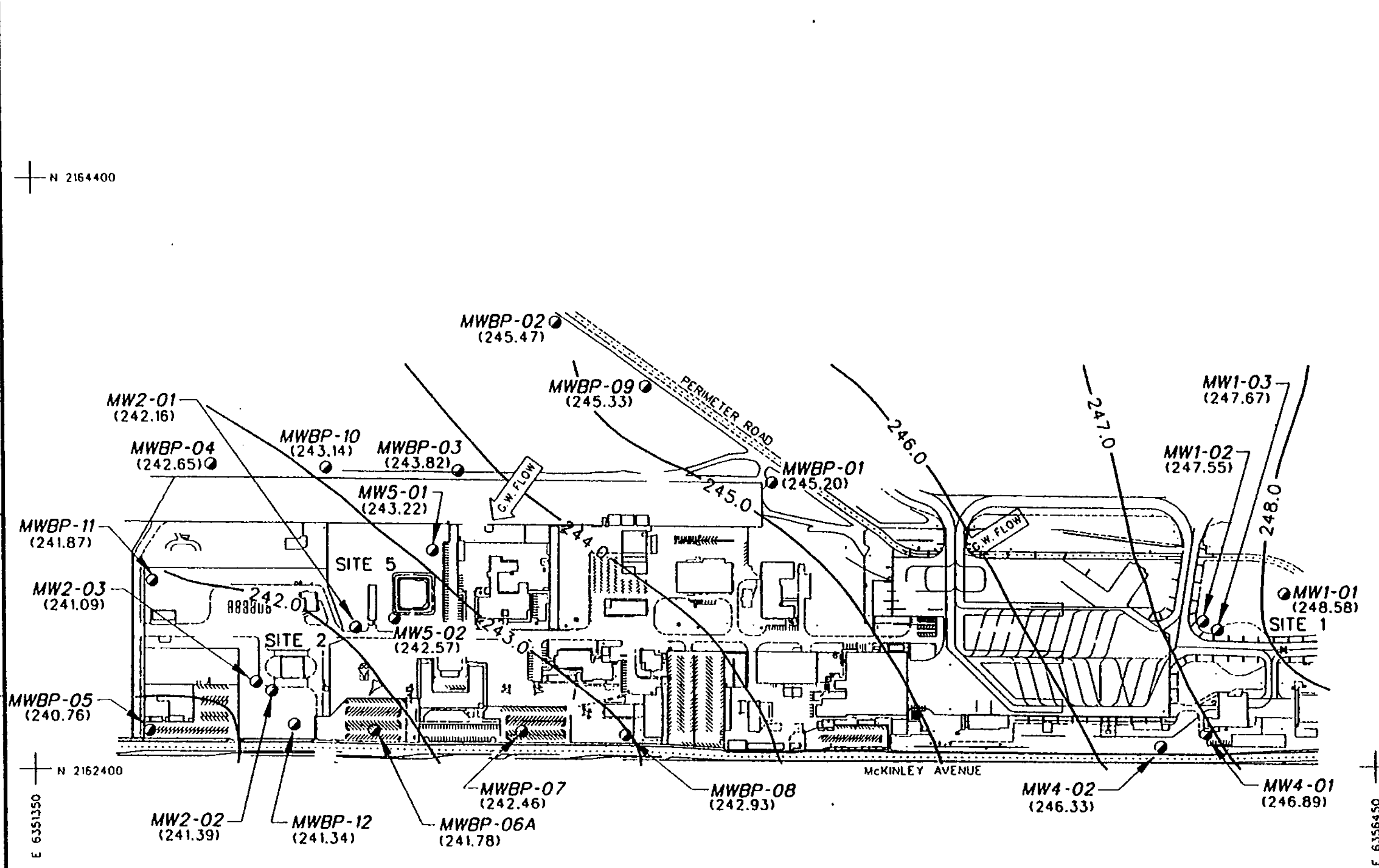
FIGURE E-6
GROUNDWATER ELEVATION CONTOURS FOR WATER TABLE WELLS, DECEMBER 1993

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

IT INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/16/94	DATE LAST REV.:	DRAFT. CHCK. BY: CTUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.026
DRAWN BY: P. TERRY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

409724ES.026 16:41 Apr. 3, 1996 KHB



LEGEND:

MW2-01 (242.16)	MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (ft. MSL)
—244.0—	GROUNDWATER ELEVATION CONTOUR
G.W. FLOW	GROUNDWATER FLOW DIRECTION

CONTOUR INTERVAL - 1.0 FT.

NOTES:

1. "B" AND "C" SERIES WELLS ARE NOT SHOWN.

SCALE:

0 400 800FEET

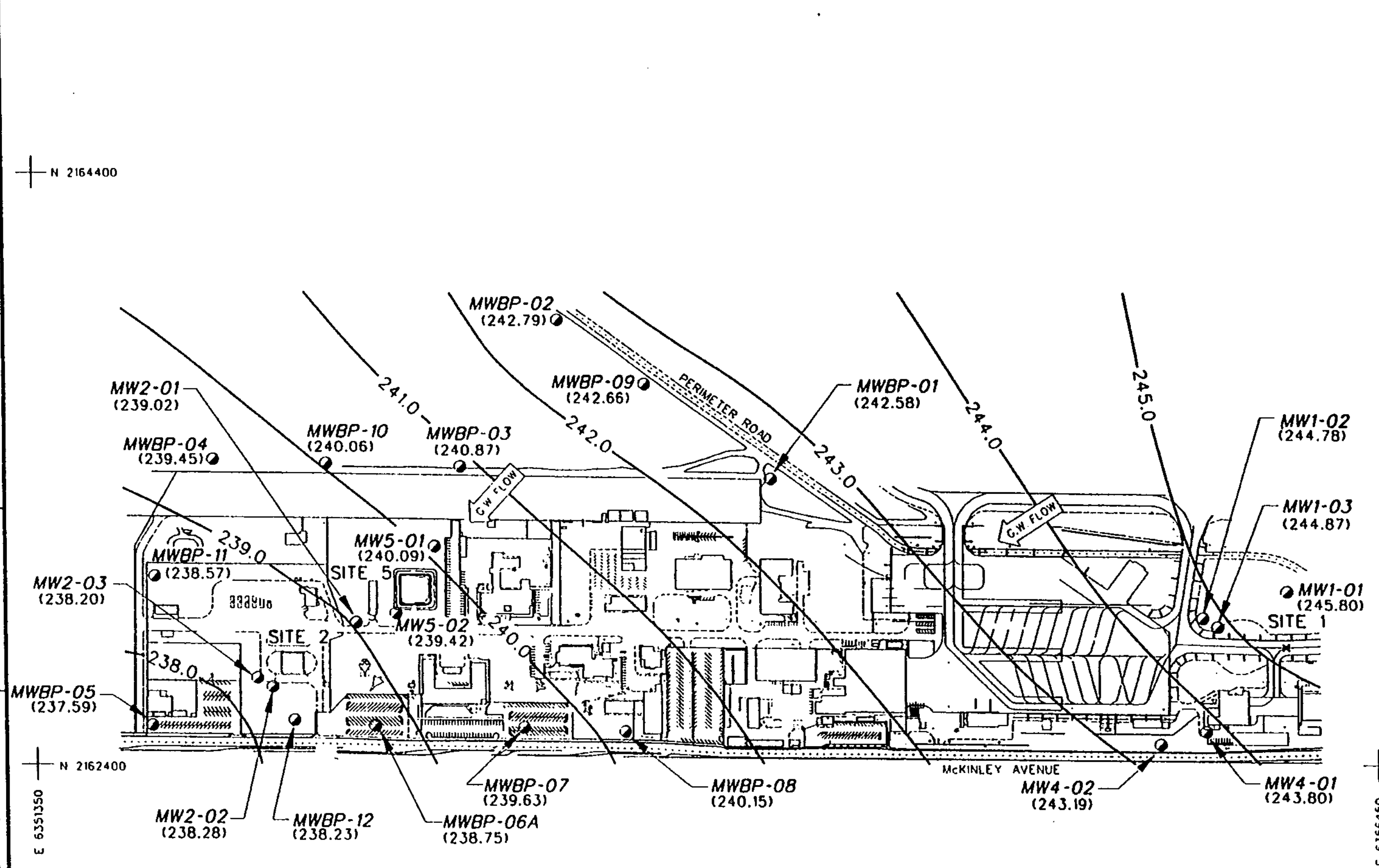
FIGURE E-7
GROUNDWATER ELEVATION CONTOURS FOR WATER TABLE WELLS, MARCH 1994

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

IT INTERNATIONAL TECHNOLOGY CORPORATION

DWG. NO.: 409724ES.027	PROJ. NO.:409724
INITIATOR: S. LOGAN	PROJ. MGR.: D. BURTON
DRAFT. CHCK. BY: CTUMLIN	ENGR. CHCK. BY: S. LOGAN
DATE LAST REV.:	DRAWN BY:
STARTING DATE: 11/16/94	DRAWN BY: P. TERRY

409724ES.027 16:44 Apr. 3, 1996 KHB



LEGEND:

MW2-01 (239.02)	MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (ft. MSL)
244.0	GROUNDWATER ELEVATION CONTOUR
G.W. FLOW	GROUNDWATER FLOW DIRECTION

CONTOUR INTERVAL = 1.0 FT.

NOTES:

1. "B" AND "C" SERIES WELLS ARE NOT SHOWN.

SCALE:

0 400 800FEET

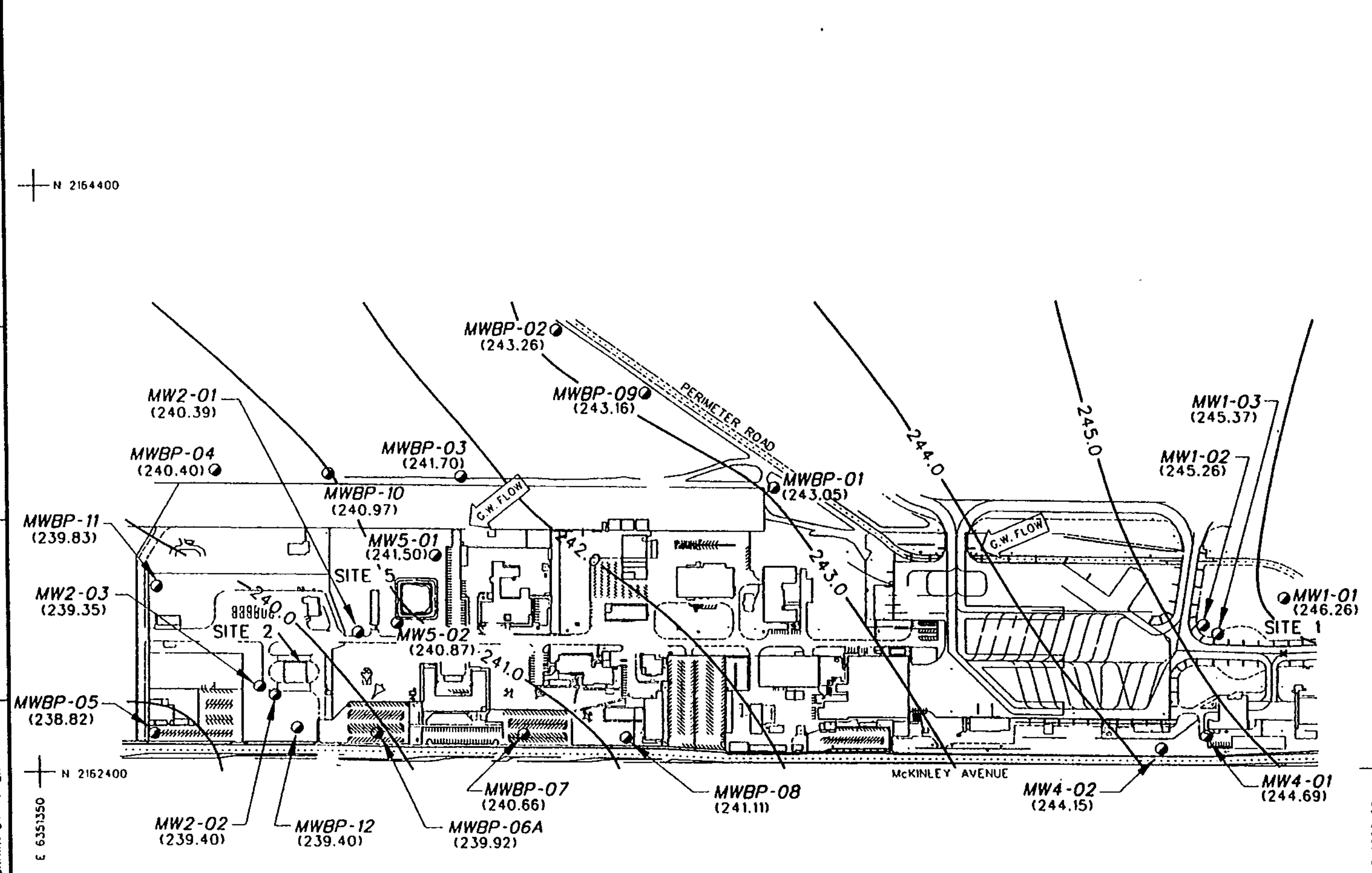
FIGURE E-8
GROUNDWATER ELEVATION CONTOURS FOR WATER TABLE WELLS, DECEMBER 1994

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/16/94	DATE LAST REV.:	DRAFT. CHCK. BY: CTUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.028	
DRAWN BY: P. TERRY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724	

409724ES.028 16:47 Apr. 3, 1996 KHB



LEGEND:

MW2-01 (240.39)	MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (ft. MSL)
244.0	GROUNDWATER ELEVATION CONTOUR
G.W. FLOW	GROUNDWATER FLOW DIRECTION

CONTOUR INTERVAL = 1.0 FT.

NOTES:

1. "B" AND "C" SERIES WELLS ARE NOT SHOWN.

SCALE:

0 400 800FEET

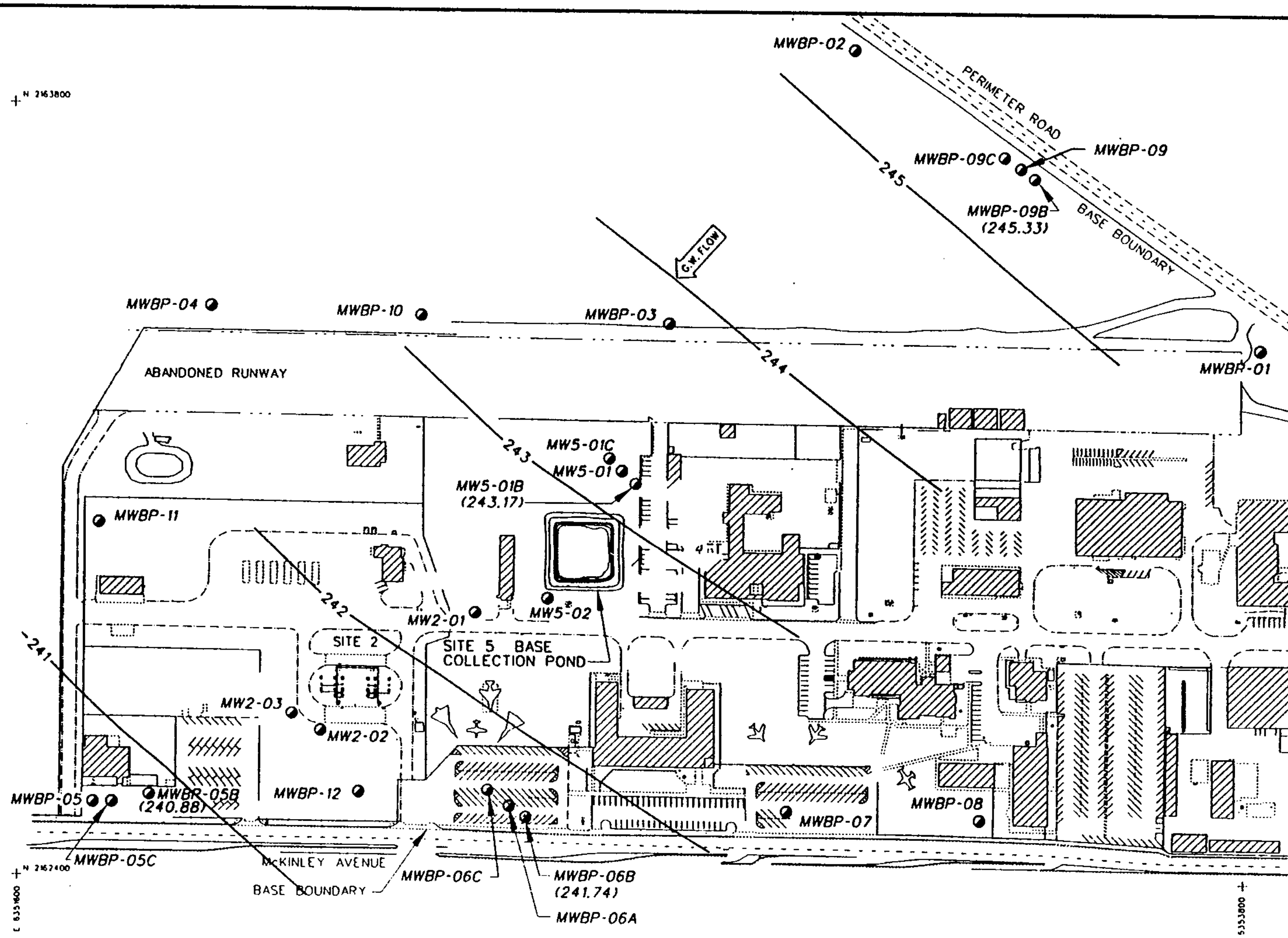
FIGURE E-9
GROUNDWATER ELEVATION CONTOURS FOR WATER TABLE WELLS, FEBRUARY 1995

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/16/94	DATE LAST REV.:	DRAFT. CHCK. BY: CTUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724ES.029
DRAWN BY: P. TERRY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.:409724

409724ES 029 08:26 Apr. 4, 1996 KHB



LEGEND:

MWBP-03	WATER TABLE MONITORING WELL
MW5-01B (243.17)	MONITORING WELL INSTALLED TO APPROX. 115 FT. DEPTH WITH MEASURED GROUNDWATER ELEVATION (FT. MSL)
MW5-01C	MONITORING WELL INSTALLED TO APPROX. 147 FT. DEPTH
G.W. FLOW	GROUNDWATER FLOW DIRECTION
245	GROUNDWATER ELEVATION CONTOUR

CONTOUR INTERVAL: 1.0 FT

SCALE: 0 200 400 FEET

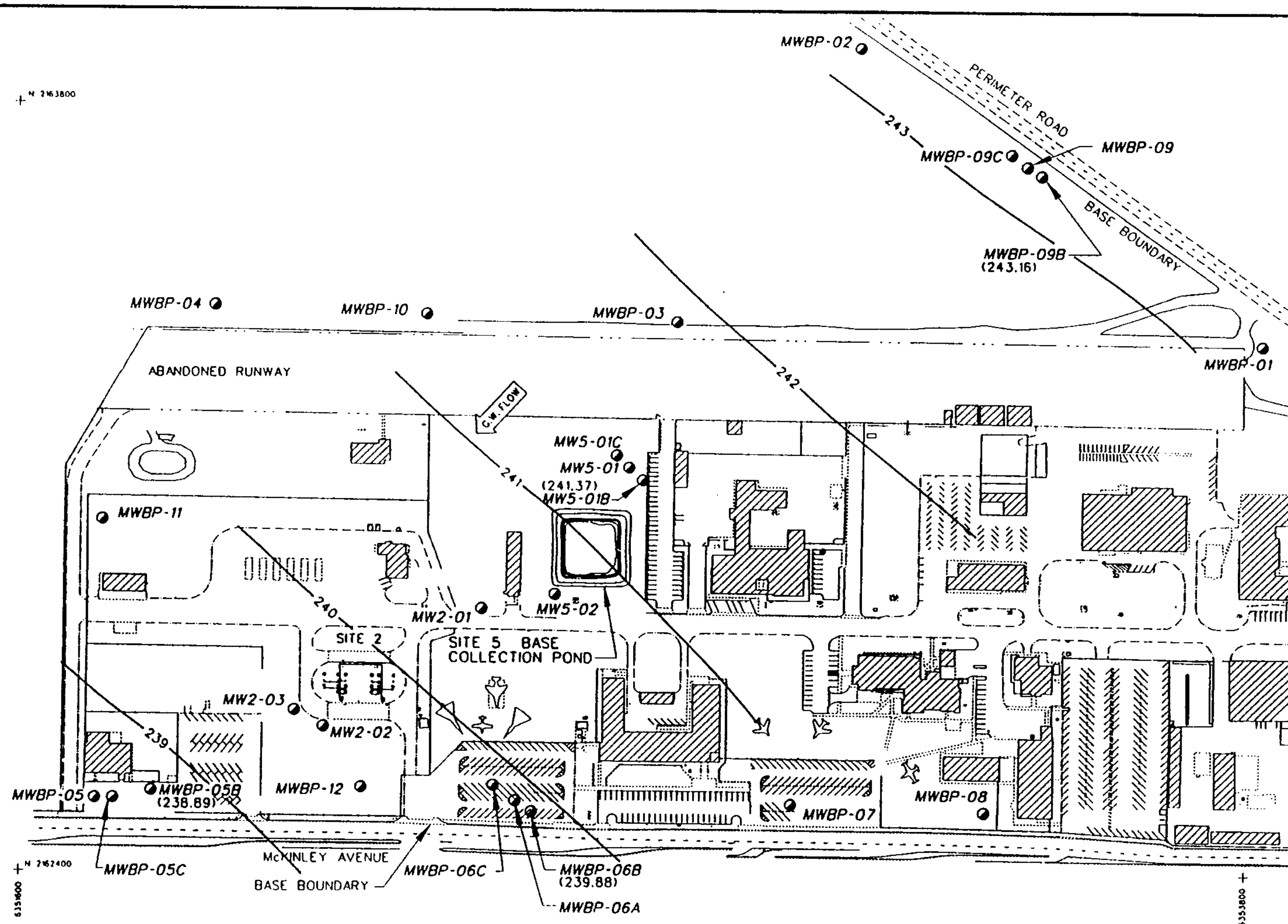
FIGURE E-10
GROUNDWATER ELEVATION CONTOURS FOR "B" SERIES WELLS FOR MARCH, 1994

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

IT INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE 11/20/95	DATE LAST REV.:	DRAFT CHCK. BY: C. TUMLIN	INITIATOR S. LOGAN	DWG. NO.:409724ES.030
DRAWN BY: K. BLAIR	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.:409724

409724ES.030 11:33:23 Nov 20 1995 KHB



LEGEND:

MWBP-03	EXISTING WATER TABLE MONITORING WELL
MW5-01B (241.37)	MONITORING WELL INSTALLED TO APPROX. 115 FT. DEPTH WITH MEASURED GROUNDWATER ELEVATION (FT MSL)
MW5-01C	MONITORING WELL INSTALLED TO APPROX. 147 FT. DEPTH
G.W. FLOW	GROUNDWATER FLOW DIRECTION
241	GROUNDWATER ELEVATION CONTOUR

CONTOUR INTERVAL: 1.0 FT

SCALE:

0 200 400 FEET

FIGURE E-11

GROUNDWATER ELEVATION CONTOURS FOR "B" SERIES WELLS FOR FEBRUARY, 1995

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

IT INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/20/95	DATE LAST REV.:	DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: S. LOGAN	DWG. NO 409724E5.033
DRAWN BY: K. BLAIR	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ MGR.: D. BURTON	PROJ. NO 409724

409724E5.033 08:28:35 Nov 22 1995 KHB

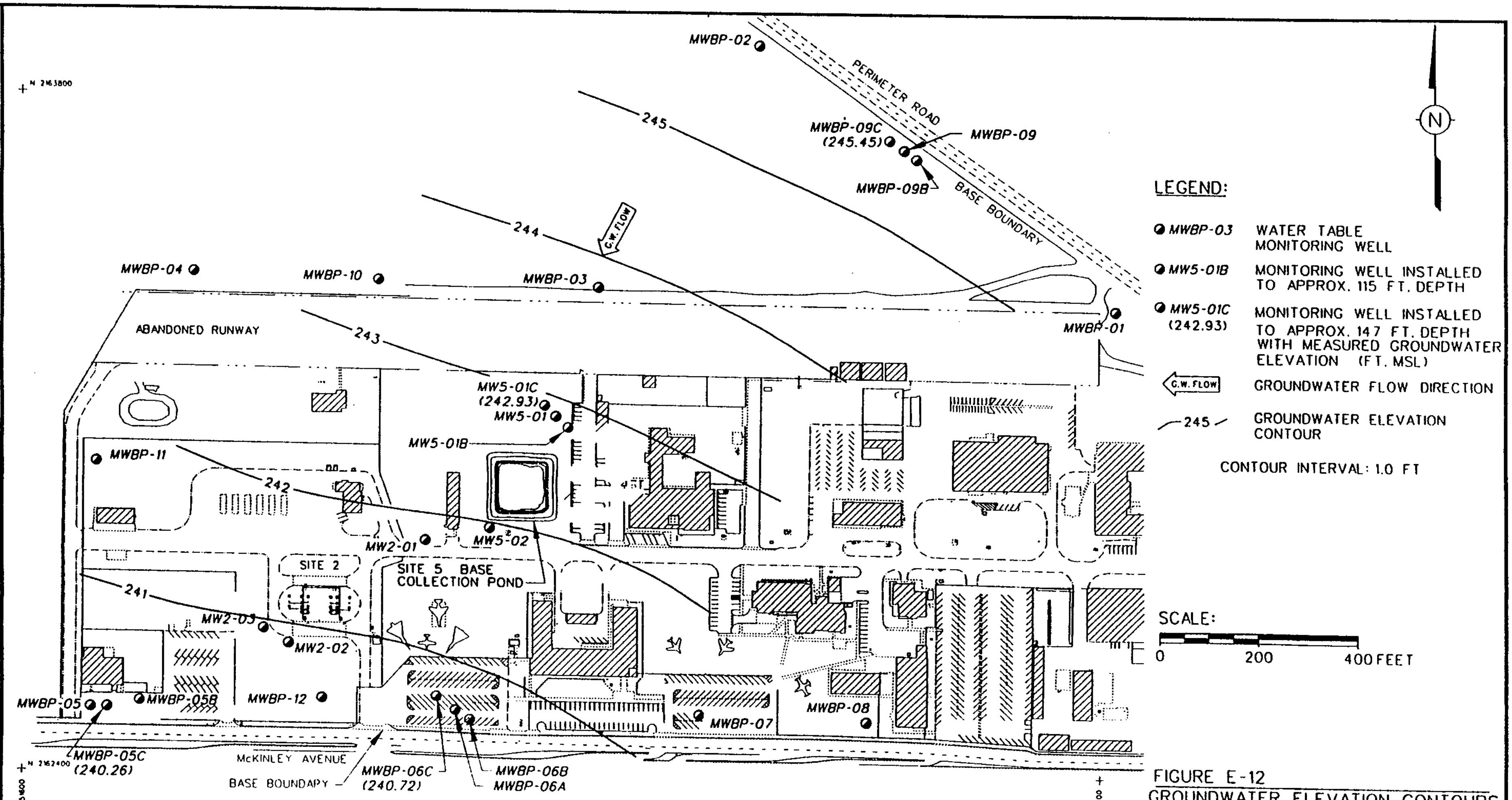


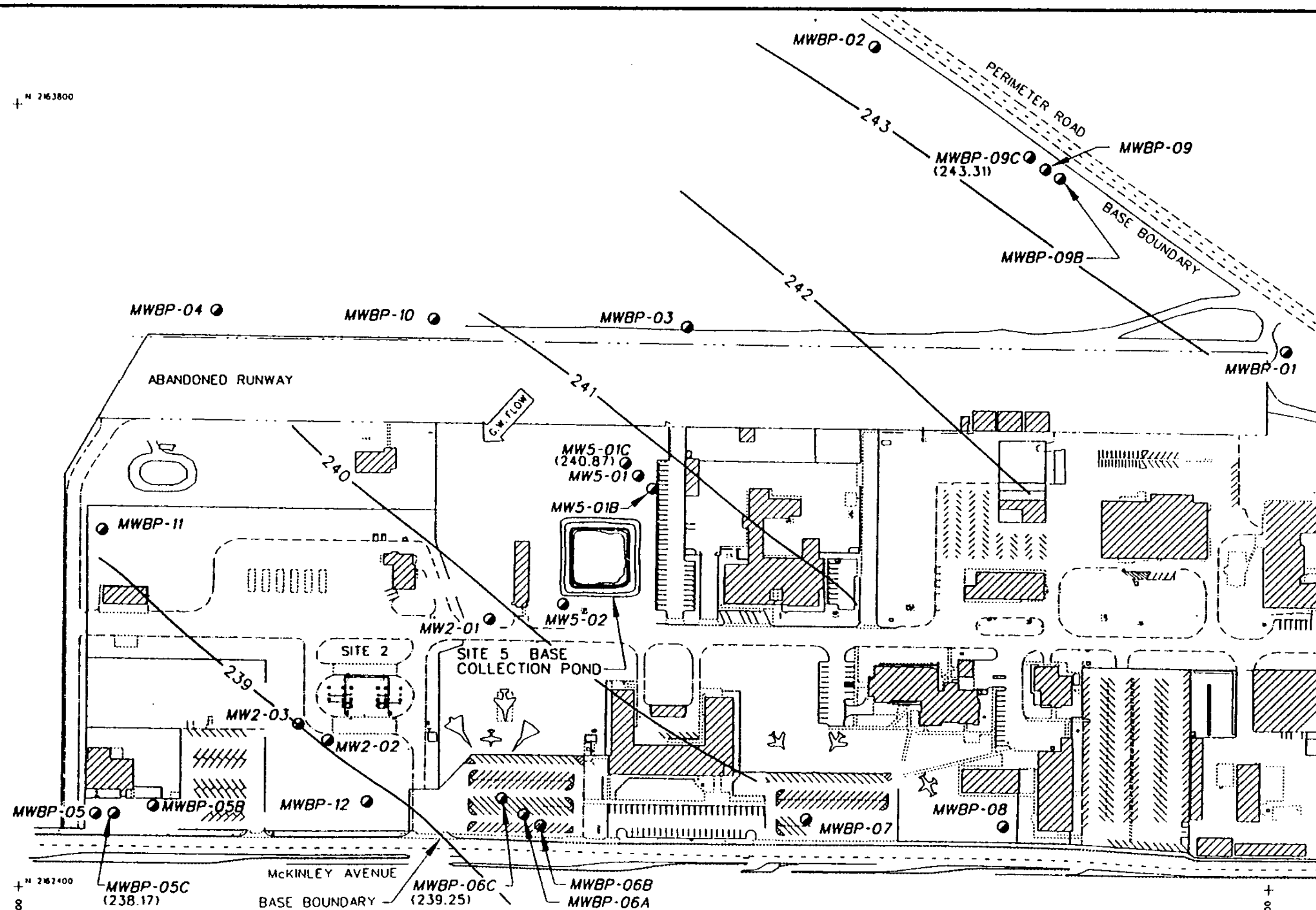
FIGURE E-12
GROUNDWATER ELEVATION CONTOURS FOR "C" SERIES WELLS FOR MARCH, 1994

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/20/95	DATE LAST REV.:	DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: S. LOGAN	DWG. NO.:409724ES 031
DRAWN BY: K. BLAIR	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

409724ES 031 13:10:50 Nov 20, 1995 KHB



LEGEND:

- MWBP-03 — EXISTING WATER TABLE MONITORING WELL
- MW5-01B — MONITORING WELL INSTALLED TO APPROX. 115 FT. DEPTH
- MW5-01C (240.87) — MONITORING WELL INSTALLED TO APPROX. 147 FT. DEPTH WITH MEASURED GROUNDWATER ELEVATION (FT MSL)
- G.W. FLOW — GROUNDWATER FLOW DIRECTION
- 241 — GROUNDWATER ELEVATION CONTOUR

CONTOUR INTERVAL: 1.0 FT

SCALE:
0 200 400 FEET

FIGURE E-13
GROUNDWATER ELEVATION CONTOURS FOR "C" SERIES WELLS FOR FEBRUARY, 1995

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

IT INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 11/20/95	DATE LAST REV.:	DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: S. LOGAN	DWG. NO. 409724ES.032
DRAWN BY: K. BLAIR	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR: D. BURTON	PROJ. NO. 409724

409724ES.032 08:30:30 Nov 22, 1995 KHB

APPENDIX F

BORING LOGS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-01/MW5-01	COORDINATES: SITE 5, NORTH	DATE: 10/2/92
ELEVATION: 322.7	GWL DEPTH: DATE:	DATE STARTED: 10/2/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 10/2/92
DRILLING METHODS: 6" HSA, 18" DRIVE SAMPLER/5' SPLIT BARREL		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0				Moderate brown, silty SAND, fine grained sand, dense, moist micaceous.	sm		18" X 2" drive samples
5		32 50/4"	0.5				
				Moderate brown sandy SILT, fine grained sand, firm, moist, micaceous.	ml		
10		7 14 16	1.5				
				Moderate brown silty SAND, fine grained sand, dense, moist micaceous	sm		
				Reddish brown SAND with some silt, med-coarse grained sand, loose, moist, micaceous.	sp		
15		7 20 24	1.5	Moderate brown silty SAND, fine grained, dense, moist, micaceous.	sm		
				Grayish brown SAND with some silt, fine-coarse grained sand, approaches well graded, loose, moist, granitic mineralogy.	sp		
20		6 12 12	1.5				Gradational Contact
				Reddish brown silty SAND, fine-coarse grained, loose, moist, micaceous.	sm		
25		9 12 14	1.5				
30							Increasing drilling resistance

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-01/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-01/MW5-01	COORDINATES: SITE 5, NORTH	DATE: 10/2/92
ELEVATION: 322.7	GWL DEPTH: DATE:	DATE STARTED: 10/2/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 10/2/92
DRILLING METHODS: 6" HSA, 18" DRIVE SAMPLER/5' SPLIT BARREL		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30		6 10 12	1.5				Difficult drilling 28' - 30'
				Reddish brown silty SAND, fine grained, dense, moist, moderately well cemented in 2 mm-2 cm aggregates.	sm		
35		24 50/3"	0.75				Difficult drilling 30' - 35'
				Grayish brown sandy SILT, fine grained sand, firm, moist, micaceous, weakly cemented locally.	ml		
40		30 50/4"	0.75				Ran plugged augers 40' - 45'
45			2.0				Began using 5' core barrel
50			1.5				
55			2.0	Grayish brown silty SAND, fine grained, loose, moist, micaceous.	sm		
				Grayish brown SAND, coarse grained, loose, moist, granitic mineralogy	sp		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-01a/FANG/drw/mb/8/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-01/MW5-01	COORDINATES: SITE 5, NORTH	DATE: 10/2/92
ELEVATION: 322.7	GWL DEPTH: DATE:	DATE STARTED: 10/2/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 10/2/92
DRILLING METHODS: 6" HSA, 18" DRIVE SAMPLER/5' SPLIT BARREL		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60			2.0	Grayish brown SAND with some silt, medium grading to coarse grained sand at 65.0 ft, loose, moist, granitic mineralogy.	sp		5' core barrel
65			0				Drilled with plugged augers 65' - 70'
				Grayish brown SILT with some sand, fine grained sand, firm, moist, micaceous.	ml		
70		10 33	1.0				Resume sampling with 2" X 18" drive sampler
				Grayish brown SAND with some silt, fine-medium grained, dense, moist, micaceous.	sp		
75		14 25 25	1.5				
				Grayish brown silty SAND, fine grained, wet, micaceous.			
80		13 23 20	1.5		sm		Groundwater 80.5 ft. 12:54, 10/2/92
85		8 12 12	1.5	Total Depth = 85 ft., 13:08 10/02/92 Grayish brown, silty SAND, fine grained, wet, micaceous, weakly cemented in 2 mm - 2 cm aggregates.	sm		Borehole reamed to 91.5 ft. to install well.
90							

NOTES:

Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

Completed as monitoring well MW5-01 on 10/8/92.

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-01b/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-02/MW5-02	COORDINATES: SITE 5, SOUTH	DATE: 9/29/92
ELEVATION: 324.2	GWL DEPTH: DATE:	DATE STARTED: 9/29/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/30/92
DRILLING METHODS: 6" HSA; 5' SPLIT BARREL		PAGE 1 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0			2.5	Moderate brown, silty SAND, fine grained, loose, dry.	sm		
5				Reddish brown silty SAND, fine-medium grained, loose, moist, micaceous.	sm		
			2.0	Moderate brown silty SAND, fine-medium grained, loose, moist.	sm		
10			1.0				
15			1.5				
20			1.5				
				Moderate brown SAND with silt, medium grained, loose, moist, granitic mineralogy.	sp		
25							
				Moderate brown silty SAND, fine grained, dense, moist. (From cuttings)	sm		Drilled 27 ft. - 40 ft. with plugged augers
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-02/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-02/MW5-02	COORDINATES: SITE 5, SOUTH	DATE: 9/29/92, 9/30/92
ELEVATION: 324.2	GWL DEPTH: DATE:	DATE STARTED: 9/29/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/30/92
DRILLING METHODS: 6" HSA; 5' SPLIT BARREL		PAGE 2 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			0				
35			0				
40		52/18"		Grayish brown silty SAND, fine grained, dense, wet, micaceous.	sm		18" drive sample
			0				
45			2.0				Drilled 41.5 ft. to 45 ft. with plugged augers
				Grayish brown SAND, fine to coarse grained, approaches well graded, loose, moist, micaceous.	sp		Drilled 45 ft. - 90 ft. using 5 ft. split barrel
50			2.5	Grayish brown sandy SILT, fine grained sand, firm, moist.	ml		
				Grayish brown silty SAND, medium grained, dense, moist, micaceous.	sm		
55			2.0	Grayish brown sandy SILT, fine-medium grained sand, firm, moist, weakly cemented in 2 mm - 2 cm aggregates.	ml		
				Grayish brown SAND, medium grained, loose, moist, micaceous.	sp		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-02a/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-02/MW5-02	COORDINATES: SITE 5, SOUTH	DATE: 9/30/92
ELEVATION: 324.2	GWL DEPTH: DATE:	DATE STARTED: 9/29/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/30/92
DRILLING METHODS: 6" HSA; 5' SPLIT BARREL		PAGE 3 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60			2.5				
				Grayish brown sandy SILT, fine grained sand, firm, moist, micaceous.	ml		
65			2.5	Grayish brown sandy SILT, mostly fine, some coarse grained sand, quartz, firm, moist, micaceous, weakly cemented aggregates from 67.5 ft. to 69.5 ft.	ml		
70			3.0	Weakly cemented 2 mm - 2 cm aggregates 72.0 ft. - 72.5 ft.			▽ Water 72.0 ft. 10:25; 9/30/92 (wetting front)
75			2.0	Grayish brown sandy SILT, fine grained sand, firm, moist, weakly cemented aggregates 78 ft. - 80 ft.	ml		
80			3.0				
				Grayish brown SAND with some silt, fine grained sand, loose, wet, micaceous.	sp		▼ Groundwater 83.0 ft. 11:12; 9/30/92
85			5.0	Grayish brown silty SAND, fine - medium grained, dense, wet, weakly cemented in blocky aggregates.	sm		5 ft. split barrel
				Grayish brown SAND with some silt, fine grained sand, loose, wet, micaceous.	sp		
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

SB5-02B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-02/MW5-02	COORDINATES: SITE 5, SOUTH	DATE: 9/30/92
ELEVATION: 324.2	GWL DEPTH: DATE:	DATE STARTED: 9/29/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 10/1/92
DRILLING METHODS: 6" HSA; 5' SPLIT BARREL		PAGE 4 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
90		28 50/5"		Grayish brown silty SAND, fine-medium grained, dense, wet, micaceous.	sm		2" X 18" drive sample 90.0 ft. - 91.5 ft.
95				Grayish brown sandy SILT, firm, wet, micaceous. Total Depth = 94 ft.; 10:01; 10/01/92			(Collected for logging purposes only) 2" X 18" drive sample 94.0 ft. - 95.5 ft. for log
100							
105							
110							
115							
120							

NOTES:

Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

Completed as monitoring well MW5-02 on 10/2/92.

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-02C/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-03	COORDINATES: SITE 5	DATE: 9/24/92
ELEVATION: 311.7	GWL DEPTH: DATE:	DATE STARTED: 9/24/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/24/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0–5			1.5	Light brown silty SAND, fine grained, loose, dry, micaceous.	sm		
5–10			1.5	Light brown silty SAND, fine grained, loose, moist, micaceous.	sm		
10–15			2.5	Reddish brown silty SAND, fine-medium grained, loose, moist, micaceous, very weakly cemented in some areas.	sm		
15–20			3.0	Reddish brown silty SAND, fine grained, loose, moist, micaceous.	sm		
20–25			4.0	High moisture content at contact			Near saturation
				Reddish brown sandy SILT, fine grained sand, firm, moist, micaceous, some mottling and weak cementation locally.	ml		
25–30			2.5	Reddish brown silty SAND, fine-medium grained, dense, wet, cemented in 2 mm - 2 cm aggregates.	sm		∇ Perched water at 27.5 ft.; 16:16; 9/24/92 (wetting front)

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-03/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-03	COORDINATES: SITE 5	DATE: 9/24/92
ELEVATION: 311.7	GWL DEPTH: DATE:	DATE STARTED: 9/24/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/24/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			2.5	Grayish brown sandy SILT, fine grained sand, firm, moist, weakly cemented locally.	ml		
				Grayish brown SAND with silt, fine grained sand, loose, moist	sp		
35			2.5	Grayish brown sandy SILT, fine grained sand, firm, moist, weakly cemented.	ml		
				Grayish brown SAND with silt, fine-medium grained, loose, moist.	sp		
40			2.5	Grayish brown silty SAND, fine grained, dense, moist, weakly cemented.	sm		
				Grayish brown SAND with silt, fine-medium grained, loose, moist.	sp		
45			2.5	Grayish brown silty SAND, fine grained, loose, moist.	sm		
50			2.5	Grayish brown silty SAND, medium grained, loose, moist	sm		
55			3.0	Grayish brown silty SAND, medium-coarse grained, loose, moist.	sm		
				Grayish brown SILT with sand, fine grained sand, firm, moist, weakly cemented from 63 ft. to 64 ft.	ml		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-03A/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-03	COORDINATES: SITE 5	DATE: 9/24/92
ELEVATION: 311.7	GWL DEPTH: DATE:	DATE STARTED: 9/24/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/24/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60							
				Grayish brown silty SAND, fine grained, loose, wet.	sm		▼ First groundwater 64 ft. 17:23;9/24/92
65				Total Depth = 65 ft.; 17:25; 9/24/92			
70							
75							
80							
85							
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-03B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-04	COORDINATES: SITE 5	DATE: 9/28/92
ELEVATION: 312.1	GWL DEPTH: DATE:	DATE STARTED: 9/28/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/29/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0			5.0	Moderate brown, silty SAND, fine-medium grained, loose, wet, micaceous.	sm		Surface water recharge
5			3.0	Moderate brown silty SAND, fine-medium grained, loose, wet (not fully saturated), micaceous.	sm		
10			2.5	Reddish brown silty SAND, fine grained, dense, moist, micaceous.	sm		
15			2.5	Reddish brown sandy SILT, fine grained sand, firm, moist, micaceous.	ml		
20			3.0	Reddish brown silty SAND, fine-medium grained, loose, moist.	sm		
				Reddish brown sandy SILT, fine grained sand, firm, moist, micaceous, mottling and weak cementation locally.	ml		
25			3.0	Reddish brown silty SAND, fine-medium grained, dense, moist, micaceous, weakly cemented.	sm		
				Grayish brown silty SAND, fine grained, loose, moist, micaceous.	sm		
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-04/FANG/drw/mb/8/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-04	COORDINATES: SITE 5	DATE: 9/28/92
ELEVATION: 312.1	GWL DEPTH: DATE:	DATE STARTED: 9/28/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/29/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			3.0				
				Gray brown sandy SILT, fine-medium grained sand, firm, moist, micaceous, weakly cemented in 2 mm - 2 cm aggregates.	ml		
35			2.5	Gray brown silty SAND, fine-medium grained, loose, moist, 1" silt beds, weakly cemented from 38.0 ft. - 38.5 ft.	sm		
40			2.5	Gray brown SAND with some silt, fine-medium grained, loose, moist, micaceous.	sp		
				Gray brown sandy SILT, fine grained sand, firm, moist, micaceous.	ml		
45			3.0	Gray brown sandy SILT, fine grained sand, firm, moist, micaceous, weakly cemented locally in 2 mm - 2 cm aggregates.	ml		
50			2.5	Gray brown silty SAND, fine grained, dense, moist, micaceous, weakly cemented locally in 2 mm - 2 cm aggregates.	sm		
55			3.0	Reddish brown SAND with silt, medium grained, loose, moist.	sp		
				Grayish brown silty SAND, fine grained, moist, micaceous, weakly cemented locally in 2 mm - 2 cm aggregates. Increasing moisture.	sm		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-04	COORDINATES: SITE 5	DATE: 9/28/92
ELEVATION: 312.1	GWL DEPTH: DATE:	DATE STARTED: 9/28/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/29/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60			2.5				
				Gray brown SAND with silt, fine grained, loose, wet, micaceous.	sp		Groundwater 64 ft; 10:03; 9/29/92
65				Total Depth = 65 ft.; 10:03; 9/29/92			
70							
75							
80							
85							
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-04B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-05	COORDINATES: SITE 5	DATE: 9/23/92
ELEVATION: 311.2	GWL DEPTH: DATE:	DATE STARTED: 9/23/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/23/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0			2.0	Light brown silty SAND, medium grained, loose, moist, micaceous.	sm		
5			1.5				
10			4.0	Reddish brown silty SAND, fine-medium grained, loose, moist, micaceous, trace organic particles (?). Grading to:	sm		
15			4.5	Reddish brown sandy SILT, fine-medium grained sand, moist, micaceous, trace organic particles (?).	ml		
20			2.5	Reddish brown SAND with silt, medium grained, wet, loose, micaceous.	sp		Perched water at 22.5 ft.; 14:35; 9/23/92 (wetting front)
				Reddish brown sandy SILT, fine-medium grained sand, moist, micaceous.	ml		
25			3.5	Grayish brown silty SAND, fine-coarse grained, moist, micaceous, cemented in 2 mm - 2 cm aggregates.	sm		
				Reddish brown silty SAND, fine-medium grained, moist, micaceous.	sm		Perched water at 27.5 ft.; 14:40; 9/23/92 (wetting front)
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-05	COORDINATES: SITE 5	DATE: 9/23/92
ELEVATION: 311.2	GWL DEPTH: DATE:	DATE STARTED: 9/23/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/23/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			2.5	Grayish brown, sandy SILT with trace clay, fine grained sand, firm, moist, micaceous.	ml		
35			3.75	Gray brown, SILT with trace fine grained sand, moist, cemented to blocky texture.	ml		
				Reddish brown sandy SILT, firm, moist, micaceous.	ml		
40			4.0	Reddish brown silty SAND, medium grained, loose, moist, micaceous.	sm		
				Gray brown SILT with trace fine sand, firm, moist.	ml		
				Reddish brown silty SAND, medium grained, loose, moist. 1 - inch lens, coarse grained sand.	sm		
45			3.0	Yellowish brown sandy SILT, fine grained sand, firm, moist.	ml		
50			2.5				
55			2.5	Gray SAND with silt, fine to medium grained, moist, dense, arkosic (granitic mineralogy).	sp		
				Gray brown sandy SILT, fine grained sand, firm, moist, micaceous.	ml		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

SB5-05A/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-05	COORDINATES: SITE 5	DATE: 9/23/92
ELEVATION: 311.2	GWL DEPTH: DATE:	DATE STARTED: 9/23/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/23/92
DRILLING METHODS: 6" OD HSA; 5' CONTINUOUS CORE SAMPLER		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60							
				Gray brown SAND with silt, fine-medium grained, loose, wet.	sp		First water at 63.5 ft. 15:55; 9/23/92
65				Total Depth = 65 ft.; 15:55; 9/23/92			
70							
75							
80							
85							
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-05B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-06	COORDINATES: SITE 5	DATE: 9/24/92
ELEVATION: 311.3	GWL DEPTH: DATE:	DATE STARTED: 9/24/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/24/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0			2.0	Brown sandy SILT, fine grained sand, soft, dry.	ml		
5			1.5	Grayish brown silty SAND, fine-medium grained, loose, moist, micaceous.	sm		
10			3.0	Reddish brown silty SAND, fine-medium grained, loose, moist, micaceous.	sm		
15			3.0				
				Reddish brown sandy SILT, fine grained sand, firm, moist, micaceous.	ml		
20			2.5				∇ Perched water at 23.0 ft.; 9/24/92 (wetting front)
				Reddish brown SAND with silt, medium grained, loose, wet, micaceous.	sp		
				Reddish brown silty SAND, fine grained, dense, moist, micaceous.	sm		
25			2.5	Reddish brown silty SAND, fine-medium grained, cemented in 1 mm - 2 cm aggregates, wet.	sm		∇ Perched water at 27.5 ft.; 9/24/92 (wetting front)
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-06/FANG/drw/mb/8/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-06	COORDINATES: SITE 5	DATE: 9/24/92
ELEVATION: 311.3	GWL DEPTH: DATE:	DATE STARTED: 9/24/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/24/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			2.5				
				Gray brown sandy SILT, fine to coarse grained sand, firm, moist.	ml		
35				Gray brown SAND with silt, fine to coarse grained, loose, moist, granitic mineralogy.	sp		
			2.5	Gray brown sandy SILT, fine grained sand, firm, moist, blocky texture, weakly cemented.	ml		
40			3.0				
45				Gray brown SAND with silt, medium-coarse grained, loose, moist, granitic mineralogy.	sp		
			2.0	Grades to fine grained SAND at 48 ft.			
50			2.0				
55			3.0	Gray brown sandy SILT, fine grained sand, firm, moist, increasing moisture with depth.	ml		Gradational contact
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-06A/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-06	COORDINATES: SITE 5	DATE: 9/24/92
ELEVATION: 311.3	GWL DEPTH: DATE:	DATE STARTED: 9/24/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/24/92
DRILLING METHODS: 6" OD HSA; 5'CONTINUOUS CORE SAMPLER		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60			2.5				
				Gray brown SAND with silt, fine grained, loose, wet.	sp		
65				Total Depth = 65 ft.; 11:15; 9/24/92			
70							
75							
80							
85							
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-06B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-07	COORDINATES: SITE 5	DATE: 9/25/92
ELEVATION: 311.4	GWL DEPTH: DATE:	DATE STARTED: 9/25/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/25/92
DRILLING METHODS: 6" OD HSA; 5'SPLIT BARREL		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0			0	Light brown silty SAND, fine grained, loose, dry, micaceous. (From cuttings)	sm		
5			1.5	Light brown, silty SAND, fine-medium grained, loose, moist, micaceous.	sm		
10			0.5				
15				Reddish brown silty SAND, fine-medium grained, loose, moist, micaceous.	sm		Water on outside of sample tube
			3.0	Reddish brown silty SAND, fine grained, loose, moist, micaceous.	sm		Water on outside of sample tube
20			3.0	Reddish brown silty SAND, fine-medium grained, dense, wet, micaceous, weakly cemented locally.	sm		∇ Perched water at 22.5 ft.; 9:43; 9/25/92 (wetting front)
25			2.5				∇ Perched water at 28.0 ft.; 9:50; 9/25/92 (wetting front)
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

SB5-07/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-07	COORDINATES: SITE 5	DATE: 9/25/92
ELEVATION: 311.4	GWL DEPTH: DATE:	DATE STARTED: 9/25/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/25/92
DRILLING METHODS: 6" OD HSA; 5'SPLIT BARREL		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			2.5	Grayish brown silty SAND, fine grained, loose, moist, micaceous, weakly cemented aggregates 32.5 ft. - 33.0 ft.	sm		
35			3.5	Grayish brown SILT with sand, fine grained sand, firm, moist, micaceous. Weakly cemented 37.0 ft. - 37.5 ft.	ml		
				Reddish brown silty SAND, fine-medium grained, dense, moist, micaceous.	sm		
40			3.0	Grayish brown silty SAND, fine grained, dense, wet, weakly cemented aggregates 2 mm - 2 cm. Grayish brown silty SAND, fine grained, loose, moist, micaceous.	sm		∇ Perched water at 42.5 ft.; 10:22; 9/25/92 (wetting front)
45			2.5	Grayish brown SAND with some silt, medium grained, loose, moist, granitic mineralogy.	sp		
50			3.5	Grayish brown silty SAND, fine grained, loose, moist, micaceous.	sm		
				Grayish brown silty SAND, medium grained, loose, moist, micaceous.	sm		
55			3.0	Grayish brown sandy SILT, fine grained sand, firm, moist, weakly cemented aggregates at 58.0 ft. - 58.5 ft.	ml		∇ Perched water at 58.5 ft.; 10:54; 9/25/92 (wetting front)
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-07A/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-07	COORDINATES: SITE 5	DATE: 9/25/92
ELEVATION: 311.4	GWL DEPTH: DATE:	DATE STARTED: 9/25/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/25/92
DRILLING METHODS: 6" OD HSA; 5'SPLIT BARREL		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60			2.0				
				Grayish brown silty SAND, fine grained, loose, micaceous.	sm		Groundwater at 64.5 ft.; 11:05; 9/25/92
65				Grayish brown SILT, firm, wet.	ml		
				Grayish brown silty SAND, fine grained, dense, wet, micaceous.	sm		Collected geotechnical sample SB5-07 65.5 ft. - 66.5 ft.
				Total Depth = 66.5 ft.; 11:14; 9/25/92			
70							
75							
80							
85							
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-07B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-08	COORDINATES: SITE 5, WEST	DATE: 10/05/92
ELEVATION: 324.6	GWL DEPTH: DATE:	DATE STARTED: 10/05/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 10/05/92
DRILLING METHODS: 6" OD HSA; 18" DRIVE SAMPLER		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0				Reddish brown silty SAND, fine grained, moist, micaceous.	sm		
5		11 12 15	1.25				
10		12 15 18	1.25	Moderate brown silty SAND, fine grained, dense, moist, micaceous, reddish mottling.	sm		
15		20 50/4"	0.75	Grayish brown sandy SILT, fine grained sand, firm, moist, micaceous, weakly cemented.	ml		
20		20 21 25	1.25	Reddish brown silty SAND, fine-medium grained, dense, moist, micaceous.	sm		
25		14 15 29					
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-08	COORDINATES: SITE 5, WEST	DATE: 10/05/92
ELEVATION: 324.6	GWL DEPTH: DATE:	DATE STARTED: 10/05/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 10/05/92
DRILLING METHODS: 6" OD HSA; 18" DRIVE SAMPLER		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30		10 10 12	1.25	Reddish brown SILT with some sand, fine grained sand, firm, moist, micaceous, with brown mottling.	ml		
35		22 50/6"	0.75	Reddish brown silty SAND, fine-medium grained, dense, moist, micaceous.	sm		
40		25/0.5"	0.25	Grayish brown SILT with some sand, fine grained sand, firm, dry, weakly cemented.	ml		Very high penetration resistance
45		22 30 30	1.5	Grayish brown SAND with some silt, fine-coarse grained, approaches well graded, loose, moist, granitic mineralogy.	sp		
50		50/5"	0				
55		8 12 18	1.25	Grayish brown silty SAND, fine grained, loose, wet, micaceous.	sm		∇ Water at 56.0 ft.; 15:17; 10/5/92 (wetting front)
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-08A/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-08	COORDINATES: SITE 5, WEST	DATE: 10/05/92
ELEVATION: 324.6	GWL DEPTH: DATE:	DATE STARTED: 10/05/92
ENGINEER/GEOLOGIST: K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 10/05/92
DRILLING METHODS: 6" OD HSA; 18" DRIVE SAMPLER		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60		15 28 35	1.25	Grayish brown silty SAND, fine with trace coarse quartz grains, dense, moist, micaceous.	sm		
65		16 20 27	1.25	Gray SAND with trace silt, coarse grained, dense, moist, granitic mineralogy.	sp		
70		16 28 35	1.5	Grayish brown SILT with some sand, fine grained sand, firm, moist, micaceous.	ml		Increasing moisture content 70.0 ft. - 71.5 ft.
75		17 23 31	1.5	Grayish brown silty SAND, fine grained, dense, wet, micaceous.	sm		∇ Water at 75.0 ft.; 16:10; 10/5/92 (wetting front)
80		8 12 21	1.5	Increasing percentage fine sand.			
				Total Depth = 85 ft.			
85		7 11 17	1.5	Grayish brown SILT with some sand, fine grained sand, firm, wet, weakly cemented, blocky.	ml		
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-08B/FANG/drw/mb/8/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-09	COORDINATES: SITE 5, SOUTH	DATE: 10/07/92
ELEVATION: 324.5	GWL DEPTH: DATE:	DATE STARTED: 10/07/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/07/92
DRILLING METHODS: 6" OD HSA; 18" DRIVE SPLIT SPOON SAMPLER		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0				Brown/light brown silty SAND, loose, dry.			
5		6 10 10	1.0	Reddish brown silty SAND, fine-medium grained, dry, medium dense, trace clay.	sm		
10		8 9 11	1.25	Some cementation evident.			
15		11 14 14	1.5	Dark reddish brown SAND, fine and medium grained, medium dense, trace silt, slightly moist	sp		
20		9 14 14	1.25	Brown, black, gray SAND, fine to coarse grained, subangular, medium dense, slightly moist			(Granitic mineralogy)
25		8 12 18	1.0	Reddish brown silty SAND, fine grained sand, dense, slightly moist, trace clay.	sm		
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-09/FANG/drw/mb/8/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-09	COORDINATES: SITE 5, SOUTH	DATE: 10/07/92
ELEVATION: 324.5	GWL DEPTH: DATE:	DATE STARTED: 10/07/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/07/92
DRILLING METHODS: 6" OD HSA; 18" DRIVE SPLIT SPOON SAMPLER		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30		10 15 14	1.25	Trace coarse grained SAND, slightly moist.			
35		12 50 X	0.8	Reddish brown silty SAND, fine grained sand, trace clay, weak cementation, slightly moist.	sm		
40		10 50 X	1	Trace coarse grained SAND, trace clay, wet (not saturated).			
				Brownish gray silty SAND, fine grained, trace coarser grains, cemented, dry.	sm		∇ Wait 20 minutes and get no water in bottom of hole. Unable to get sample. (wetting front)
45		20 55 X	0.7	Predominantly fine grained SAND, weakly cemented in nodules, slightly moist.			
50		19 50 X	0.8	Trace coarse/medium grained.			
55		10 50 X	0.8	Reddish brown silty SAND, fine to medium grained, very dense, slightly moist.	sm		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-09A/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-09	COORDINATES: SITE 5, SOUTH	DATE: 10/07/92
ELEVATION: 324.5	GWL DEPTH: DATE:	DATE STARTED: 10/07/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/07/92
DRILLING METHODS: 6" OD HSA; 18" DRIVE SPLIT SPOON SAMPLER		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60		10 26 42	1	Reddish brown silty SAND, fine and medium grained, slightly moist, very dense.			
65		12 50 X	1	Grayish brown silty SAND, fine grained, weakly cemented, hard, slightly moist.	sm		
70		16 29 40	1.5	Trace clay, dry.			
75		11 17 20	1	Gray SILT, stiff, trace fine grained sand, trace clay, dry.	ml		
80		22 50 X	1	Light grayish brown SAND, fine to coarse grained, dense, dry.	sp		
							∇ 84 ft. wet while drilling
85		7 11 22	1.5	Medium to coarse grained SAND, wet - saturated.	sp		
				Total Depth = 88 ft.			Overdrill hole to 88 ft. to obtain groundwater sample
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-09B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-10	COORDINATES: NORTH PERIMETER	DATE: 10/09/92
ELEVATION: 324.8	GWL DEPTH: DATE:	DATE STARTED: 10/09/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/12/92
DRILLING METHODS: 6" OD HSA; 18" SPLIT SPOON SAMPLER		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0				Brown silty SAND, fine to medium grained, compacted, dry.			
5		10 50 x	0.6	Brown silty SAND, fine grained, compacted, some cemented nodules, dry.	sm		
10		5 12 19	1.25	Cemented in thin layers, trace clay.			
15		4 12 16	1.3	Grades to medium grained silty SAND, trace clay, slightly moist, medium dense.	sm		
20		4 8 11	1.3	Brown silty fine and medium grained SAND, increasing clay percentage, medium dense, slightly moist.	sm		
25		8 12 15	1.25	Reddish brown silty SAND, fine grained, medium dense, slightly moist.	sm		
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-10/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-10	COORDINATES: NORTH PERIMETER	DATE: 10/09/ & 10/12/92
ELEVATION: 324.8	GWL DEPTH: DATE:	DATE STARTED: 10/09/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/12/92
DRILLING METHODS: 6" OD HSA; 18" SPLIT SPOON SAMPLER		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30		11 17 23	1.5	Reddish brown silty SAND, fine grained, trace clay, dense, some compacted nodules, no apparent cementation, dry.	sm		end 10/9/92 begin 10/12/92
35		50 X X	0.2	Cemented, very dense, dry.			Difficult drilling
40		23 50 X	1	Grayish brown SAND, with silt, fine to medium grained, very dense, dry.	sp		
45		25 50 X	0.8	Orange brown silty SAND, fine to coarse grained, weakly cemented, very dense, dry.	sm		
50		12 18 22	1	Reddish brown silty SAND, fine to medium grained, dense, slightly moist.			
55		18 27 32	1.25	Grayish brown sandy SILT, trace clay, very stiff, fine grained sand, dry.	ml		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-10A/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-10	COORDINATES: NORTH PERIMETER	DATE: 10/12/92
ELEVATION: 324.8	GWL DEPTH: DATE:	DATE STARTED: 10/09/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/12/92
DRILLING METHODS: 6" OD HSA; 18" SPLIT SPOON SAMPLER		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60		9 50 X	0.75	Gray SILT, trace clay, abundant red, brown, and black organic particles, hard, dry.	ml		
65		15 32 25	1.25	Gray with reddish brown mottling, sandy SILT, fine grained sand, trace clay, hard, dry.			
70		15 50 X	0.8	Grayish brown sandy SILT, some cementation evident, hard, dry.	ml		
75		5 9 10	1.25	Gray SAND, predominantly fine grained, some medium grained, trace silt, medium dense, slightly moist.	sp		
80		11 17 24	0.2	Gray SAND, fine and medium grained, wet.	sp		Logged from soil in very tip of shoe wet at 83 ft. ▼
85		9 12 15	1.5	Gray SAND, fine and medium grained, some cemented nodules, medium dense, wet-saturated.	sp		Overdrill to 90 ft. to facilitate GW sampling
90				Total Depth = 90 ft.			

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-11	COORDINATES: SITE 5, EAST	DATE: 10/13/92
ELEVATION: 322.3	GWL DEPTH: DATE:	DATE STARTED: 10/13/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/13/92
DRILLING METHODS: 6" OD HSA; 18" SPLIT SPOON SAMPLER		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0				Grass, roots. Brown silty SAND.			
5		18 50 x	0.7	Brown silty SAND, fine grained sand, very dense, weakly cemented, moist.	sm		
10		5 5 5	1.2	Brown silty SAND, fine to medium grained, loose, moist.	sm		
15		12 23 25	1.2	Dark grayish brown silty SAND, fine and medium grained, trace clay, dense, moist.	sm		
20		5 9 12	1.25	Brown, black, white SAND, medium to very coarse grained sand, granitic texture, slightly moist, angular to subrounded.	sp		
25		10 11 12	1.25	Dark reddish brown silty SAND, fine grained sand, medium dense, some cemented nodules, moist.	sm		
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

SB5-11/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-11	COORDINATES: SITE 5, EAST	DATE: 10/13/92
ELEVATION: 322.3	GWL DEPTH: DATE:	DATE STARTED: 10/13/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/13/92
DRILLING METHODS: 6" OD HSA; 18" SPLIT SPOON SAMPLER		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30		7 14 21	1	Reddish brown silty SAND, grades from coarse to medium to fine grained sand, dense, slightly moist.	sm		
35		50 X x	0.5	Trace clay, moist.			
40		24 50 X	0.9	Gray sandy SILT, trace clay, fine grained sand (20%), hard, dry.	ml		
45		28 50 X	0.6	Gray SAND, fine to medium grained, trace silt, some cemented nodules, moist.	sp		
				Gray sandy SILT, 10% fine sand, hard, dry.	ml		
50		18 29 34	1.25	Brown silty SAND, fine to medium grained, dense, slightly moist.	sm		
55		22 50 X	1	Brown with orange brown mottling, silty SAND, fine to medium grained, very dense, weakly cemented, slightly moist	sm		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-11	COORDINATES: SITE 5, EAST	DATE: 10/13/92
ELEVATION: 322.3	GWL DEPTH: DATE:	DATE STARTED: 10/13/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/13/92
DRILLING METHODS: 6" OD HSA; 18" SPLIT SPOON SAMPLER		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60		11 24 32	1.25	Brown silty SAND, fine to medium grained sand, trace clay, very dense, slightly moist.	sm		
65		15 50 x	1	Gray with red brown mottling clayey SILT, trace fine grained sand, 10-15% clay, low plasticity in places, hard, slightly moist.	ml		
70		20 50 X	0.9	Gray silty SAND, trace clay, predominantly fine grained sand, very dense, moist.	sm		Beach sand
75		15 50 X	0.75	Increased silt content in places, slightly moist.			
80		22 30 31	1	Gray SAND, fine and medium grained, with silt, moist, dense.	sp		80.7 ▼
							84 ∇
85		8 20 35	1.4	Brown and gray silty SAND, fine to medium grained, trace coarse grained sand, wet-saturated.	sm		
							Overdrill to 90 ft. for GW sample
90				Total Depth = 90 ft.			

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

SB5-11B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-12	COORDINATES: SITE 5, SOUTH	DATE: 10/14/92
ELEVATION: 321.4	GWL DEPTH: DATE:	DATE STARTED: 10/14/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/15/92
DRILLING METHODS: 6" OD HSA; 18" SPLIT SPOON SAMPLER		PAGE 1 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0				Grass, roots, red brown silty SAND.			
5		22 60 X	0.5	Reddish brown silty SAND, fine grained sand, very dense, cemented, dry.	sm		
10		15 27 35	1	Gray silty SAND, fine grained, very dense, cemented in places, slightly moist.	sm		
15		7 11 11	1.5	Reddish brown silty SAND, fine to medium grained, medium dense, no cementation evident, moist.	sm		
20		20 50 X	0.8	Dark reddish brown silty SAND, fine to medium grained, trace coarse grained sand, cemented in places, very dense, slightly moist.	sm		
25		8 8 12	1.25	No cementation present.			
30							

NOTES:

Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

Collect samples at 5,15,25 .... for logging purposes only.
Collect samples at 10, 20, 30 .... for field GC screening only.
No laboratory samples collected, except at bottom of borehole.

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-12/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-12	COORDINATES: SITE 5, SOUTH	DATE: 10/14/92
ELEVATION: 321.4	GWL DEPTH: DATE:	DATE STARTED: 10/14/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/15/92
DRILLING METHODS: 6" OD HSA; 18" SPLIT SPOON SAMPLER		PAGE 2 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30		9 12 18	1	Reddish brown silty SAND, fine to medium grained, medium dense, slightly moist.	sm		
35		18 50 X	0.5	Fine to medium grained, with some coarse grained SAND, some cemented nodules, moist.			
40		20 50 X	0.75	Grades to gray with red/orange mottling sandy SILT, fine grained sand (20%), cemented in places, hard, dry.	ml		
45		7 18 30	0.8	Brown SAND, fine to coarse grained, subangular to subrounded sand, trace gravels, dense, slightly moist.	sp		
50		24 50 X	1	Brown SAND, medium to coarse grained, grades to predominantly coarse grained at 51.0 ft., very dense, slightly moist.	sp		
55		15 21 28	1.25	Brown silty SAND, trace clay, fine grained sand, dense, slightly moist.	sm		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

Collect samples at 5,15,25 .... for logging purposes only.
Collect samples at 10, 20, 30 .... for field GC screening only.
No laboratory samples collected, except at bottom of borehole.

IT INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: SB5-12	COORDINATES: SITE 5, SOUTH	DATE: 10/14/92 - 10/15/92
ELEVATION: 321.4	GWL DEPTH: DATE:	DATE STARTED: 10/14/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 10/15/92
DRILLING METHODS: 6" OD HSA; 18" SPLIT SPOON SAMPLER		PAGE 3 OF 3

Depth (ft)	Sample Type and No.	Blows On Sampler Per (6")	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60		10 25 25	1.5	Reddish brown silty SAND, fine grained sand, cemented in places, dense, dry.	sm		
65		7 14 18	1.5	Silty SAND, fine grained, no cementation, dense, slightly moist.	sm		
70		50 X X	0.5	Gray SILT, hard, trace fine grained sand, dry.	ml		10/14/92 10/15/92
				Brown silty SAND, fine to medium grained sand, loose to medium dense, moist.	sm		
75		10 18 25	1.5	Gray and brown SILT with sand, trace clay, slightly moist.	ml		
				Brown silty SAND, fine to medium grained, trace coarse grained sand, dense, moist.			
80		5 7 7	1.1	Brown and gray SAND, fine to medium grained, with coarse grained sand, medium dense, wet at 81 ft. (saturated).	sp		Water at 81 ft. ∇ while drilling Measured at 80.9 ft. at 11:45.
85		8 12 12	1.5	Brown silty SAND, fine grained with some medium grained sand, thin silt layers interspersed, wet. Total Depth = 85 ft.	sm		
90							

NOTES:

Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

Collect samples at 5,15,25 .... for logging purposes only.
Collect samples at 10, 20, 30 .... for field GC screening only.
No laboratory samples collected, except at bottom of borehole.

INTERNATIONAL TECHNOLOGY CORPORATION

SB5-12B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-09	COORDINATES: NORTH PERIMETER	DATE: 9/9/92
ELEVATION: 325.1	GWL DEPTH: DATE:	DATE STARTED: 9/9/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/10/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER; 12" OD 8-1/4" ID HSA		PAGE 1 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0			3	Brown SAND, some silt, fine grained sand.			
5			1	Brown fine and medium grained SAND, trace coarse grained, some silt, some signs of cementation thinly layered - fine beds, dry.	sp/ sm		
10			1				
15			2	Brown fine and medium grained SAND, trace coarse grained, some silt, thinly bedded, dry.	sp/ sm		
20			3	Brown to orange brown fine and medium grained SAND, trace coarse grained, some silt, thinly bedded, dry.	sp		
25			2.5				
				Grades to medium grained, clayey silty SAND, reddish brown, stiff, 10% clay, 10-20% silt, slightly moist.	sm		
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

Ream hole to 12" OD to TD of 95 ft.

INTERNATIONAL TECHNOLOGY CORPORATION

MWBP-09/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-09	COORDINATES: NORTH PERIMETER	DATE: 9/9/92
ELEVATION: 325.1	GWL DEPTH: DATE:	DATE STARTED: 9/9/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/10/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER; 12" OD 8-1/4" ID HSA		PAGE 2 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			2.5	Reddish brown silty SAND, trace clay, fine and medium grained sand, trace coarse grained, loose to medium dense, slightly moist.	sm		
35			4	Cementation begins ~ 35 ft.			
				Gray brown silty SAND/sandy SILT, hard, fine grained sand, dry, obvious cementation.	sm/ml		
40			2	Reddish brown silty SAND, fine and medium grained sand loose, slightly moist, finely bedded.	sm		No calcareous adhesive noticed on particles. Simply very compacted. Effort is required to break. Break easily in horizontal, along bedding planes, but not vertically.
				Grades to predominantly coarse grained SAND, angular to subrounded, slightly moist, loose, some layers of high compaction (no obvious cementation).	sp		
45			2				
50			2	Grades to fine and medium grained SAND, trace silt, trace coarse grained sand, thinly bedded, somewhat compacted, dry.			
55				Brown, light brown sandy SILT, trace clay, laminated, highly compacted, predominantly fine grained sand (~ 30%).	sm		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

Ream hole to 12" OD to TD of 95 ft.

INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-09	COORDINATES: NORTH PERIMETER	DATE: 9/9/92
ELEVATION: 325.1	GWL DEPTH: DATE:	DATE STARTED: 9/9/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/10/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER; 12" OD 8-1/4" ID HSA		PAGE 3 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60			2.5	Light brown to light gray brown sandy SILT/silty SAND, fine grained sand, thinly bedded, highly compacted dry.	ml/ sm		
65			5	Some mottling with orange red.			
				Silty SAND, fine grained sand, slightly moist.	sm		
				Light gray brown SILT, trace clay, trace fine grained sand, trace black organic material, finely bedded, compacted, dry.	ml		
70			4	Light brown medium SAND, some fine grained, trace silt, thin compacted layers until 73 ft., fairly homogeneous, slightly moist.	sp		
75			4.5	Light gray brown stiff SILT interbedded with medium and fine grained sand, moist.	ml		
80			3	Fine SAND, trace medium grained, trace silt. Gray fine grained silty SAND, trace medium grained, loose, wet.	sp/ sm		79.8 ft. ▼ 9/11/92
85				Gray sandy SILT, trace clay, fine grained to medium grained sand (20-25%), medium stiff to stiff, moist. Increasing compaction, increasing clay to ~10% wet at 85 ft.	ml		Saturated material at 85 ft. 85 ft. ∇ 9/9/92
			5	4" coarse SAND bed at 87.5 ft, saturated - wet.	sp		
				Gray medium and fine grained SAND with 10-15% silt, loose, wet.	sp/ sm		
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-09	COORDINATES: NORTH PERIMETER	DATE: 9/9/92
ELEVATION: 325.1	GWL DEPTH: DATE:	DATE STARTED: 9/9/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/10/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER; 12" OD 8-1/4" ID HSA		PAGE 4 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
90			5	Grades to sandy SILT, gray, medium stiff, wet Clayey sandy SILT with interbedded fine grained sand layers 2-4" thick, somewhat compacted saturated - wet.	ml		
95				Gray SAND, coarse to fine grained, trace silt, loose to medium stiff, wet.	sp		Collect geotechnical sample at 95 ft. - 96.5 ft.
				Total Depth = 98 ft.			
100							
105							
110							
115							
120							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

MWBP-09C/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-10	COORDINATES: NORTH PERIMETER	DATE: 9/15/92
ELEVATION: 324.2	GWL DEPTH: DATE:	DATE STARTED: 9/15/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/16/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER; REAM TO 12" DIAMETER		PAGE 1 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0			2.5	Brown silty SAND, fine to coarse grained, compacted, dry. Some cementation at 4 ft.			
5			1.5	Brown to light brown silty SAND, fine to coarse grained, compacted, some calcareous cementation, dry.	sm		
10			2.5				
15			3	Light brown silty SAND, coarse grained, trace medium and fine grained, compacted, dry.	sm		Sample to 20 ft. with 5 ft. barrel. Unable to sample further with it. Switch to 2 ft. split spoon at 25 ft.
20							
25				Brown coarse grained SAND, compacted, dry.	sp		
				Grades to reddish brown SAND, fine to coarse grained, trace gravel, trace silt, compacted, dry.	sp		
30							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

MWBP-10/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-10	COORDINATES: NORTH PERIMETER	DATE: 9/15/92 - 9/16/92
ELEVATION: 324.2	GWL DEPTH: DATE:	DATE STARTED: 9/15/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/16/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER; REAM TO 12" DIAMETER		PAGE 2 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			2	Mottled gray brown and red brown clayey SILT, low plasticity, trace very fine to fine grained sand, medium stiff, slightly moist.	ml		
			1.8	Grades to reddish brown silty SAND, trace clay, fine to medium grained sand, medium dense, dry.			
35			2	Thin silt lenses (3-4") interbedded.	sm		
			2	Increasingly coarser silty SAND, dry, medium to coarse grained sand.			
40				Reddish brown to red SAND, medium to coarse grained with white quartz.	sp		
			1.8	Coarse SAND and gravel at 41.5 ft.			
			2	Reddish brown SAND and gravel, fine to coarse grained sand, angular to subangular, dry. White quartz throughout.			
45			2	Grades to fine and medium grained SANDS at 46 ft. with trace gravel and coarse sands.	sp		Drill to 45 ft. with 6" augers. Ream to 12" here and continue to TD with 12" only.
			1.6	Gray SILT, stiff to very stiff, thin vertical coarse grained sand channel from 48.5 - 49 ft. (red to orange red), slightly moist.	ml		
50			1.8	Brown silty SAND, fine to medium grained, subrounded sands, loose to medium dense, slightly moist, decreasing silt with depth.	sm		
			2				
55				Mottled gray and reddish brown clayey sandy SILT, stiff, fine grained sand, low to no plasticity, moist.	ml		
			2	Grades to brown silty fine grained SAND, dense, slightly moist.	sm		
			2	Trace clay at 59.0 ft.			
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

MWBP-10A/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG
BORING NUMBER: MWBP-10	COORDINATES: NORTH PERIMETER — DATE: 9/16/92
ELEVATION: 324.2	GWL DEPTH: DATE: — DATE STARTED: 9/15/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE: — DATE COMPLETED: 9/16/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER; REAM TO 12" DIAMETER	PAGE 3 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60			2	Trace clay to 61 ft. Brown to reddish brown SAND, fine grained, dense, dry.	sm		
			2	Gray clayey SILT, soft to medium stiff, low plasticity, slightly moist.	ml		
				Gray and reddish brown SAND, fine grained, dense, dry.	sp		
65			2	Mottled gray and reddish brown clayey SILT, stiff, low plasticity, slightly moist, orange organic fibers at 66.5 ft.	ml		
			2	Decreasing clay content.			
70			1.5	Gray fine grained SAND, trace silt, trace coarser grained sand.	sp		Beach sand
			1.5				
75			2	Abrupt change to predominantly white/gray medium grained SAND, dry.	sp		
			2	Grades to coarse and medium grained SAND, slightly moist, loose, angular to subrounded.			
80			2	Grades to coarse grained SAND at 81.0 ft., subangular to rounded. Very moist at 81.0 ft.			
				Gray SILT, trace sand, trace clay, moist.	ml		
			1.6	Brown and gray SAND, fine to medium grained sand, very moist.			
85			2	Medium to coarse grained SAND, wet at 84 ft.	sp		Wet at 84 ft.
90							

NOTES:

Drilling Contractor: Spectrum Exploration, Inc.
Driler: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

MWBP-10B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-10	COORDINATES: NORTH PERIMETER	DATE: 9/16/92
ELEVATION: 324.2	GWL DEPTH: DATE:	DATE STARTED: 9/15/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/16/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER; REAM TO 12" DIAM.		PAGE 4 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
90			1.2	Coarse grained silty SAND, saturated.	sm		18" sample 90 - 91.5' of saturated sands for geotechnical analysis.
				Gray brown sandy SILT, saturated.	ml		
				Fine to medium grained silty SAND, trace clay Possible clay at total depth	sm		
95				Total Depth = 95 ft.			
100							
105							
110							
115							
120							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-11	COORDINATES: WEST PERIMETER	DATE: 9/11/92
ELEVATION: 322.0	GWL DEPTH: DATE:	DATE STARTED: 9/11/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/14/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER		PAGE 1 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0			2	Brown to dark brown silty SAND, fine to coarse grained sand, compacted, dry.	sm		
5			1.5	Dark to light brown silty SAND, fine to medium grained sand, compacted, increasing silt content with depth, dry.	sm		
10			2	Light brown SAND, fine to medium grained sand, loose, dry.			
				Light gray brown sandy SILT, trace clay, soft to medium stiff, fine grained sand (25%), some cementation evident, dry.	ml		
15			0.75	Reddish brown, silty SAND, medium dense, fine to coarse grained sand, some cemented nodules.	sm		
20			2.5	Grades to reddish to dark brown SAND, predominantly coarse grained with medium and fine grained sand, angular to subrounded, loose, 5-10% subrounded gravel, slightly moist.			
25			4	Grades to red SAND at 26 ft. medium and coarse grained, trace gravels, trace fine sand, slightly moist.	sp		
					ml		
30							

NOTES:

Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

Ream borehole to 12" diameter to 95 ft. depth on 9/14/92.

IT INTERNATIONAL TECHNOLOGY CORPORATION

MWBP-11/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-11	COORDINATES: WEST PERIMETER	DATE: 9/11/92
ELEVATION: 322.0	GWL DEPTH: DATE:	DATE STARTED: 9/11/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/14/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER		PAGE 2 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			4	Mottled red, reddish brown and gray brown sandy SILT, medium stiff to stiff, fine grained sand, trace clay, slightly moist. Increasing clay content with depth, low plasticity.	ml		
35			4	Decreasing clay, increasing fine grained sand.			
				Reddish brown fine silty SAND, loose, slightly moist.	sm		
				Mottled reddish brown and gray brown sandy SILT, trace clay.	ml		
40			4.5	Reddish brown SAND, fine to medium grained, grades to coarse grained with depth, trace silt. Thin (6") coarse sand and gravel.	sp		
45			4.5	Mottled red, reddish brown and gray brown sandy SILT, fine grained sand (30-40%), highly compacted, thinly bedded. Thin fine grained sand beds interspersed.	ml		
50			3	Thin clayey silt (6").			
				Reddish brown fine grained SAND, some cementation, grades to coarse grained sand at 55 ft., slightly moist.	sp		
55			3	Gray brown SILT, trace fine sand, trace clay, blocky structure, dry. Silty fine grained sand 58-59 ft.	ml		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-11	COORDINATES: WEST PERIMETER	DATE: 9/11/92
ELEVATION: 322.0	GWL DEPTH: DATE:	DATE STARTED: 9/11/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/14/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER		PAGE 3 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60			2	Dark reddish brown fine and medium grained SAND, some silt, some thin bedding evident, slightly moist.	sp/ sm		
65			3	Grades to coarser grained SAND, increasing silt content, some cementation.	sp		
70			2.5	Light gray brown SILT, some fine grained sand, trace clay, blocky structure, slightly moist, some reddish brown mottling.	ml		
				Brown silty SAND, fine grained, slightly moist.	sm		
75			2.5	Gray SILT, trace sand and clay, blocky, dry, some black mottling, dry.	ml		
80			3	Gray brown SAND, fine to medium grained, loose, moist, thin sporadic bedding.	sp		82.08 ▼ 9/14/92
				Gray to brown sandy SILT, 30% sand, fine to medium grained, blocky, moist.	ml		9/11/92 ▽
85				Gray to brown silty SAND, fine grained sand, trace medium grained, moist.	sm		
				Trace clay at 89 ft., moist to wet.			
90							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-11	COORDINATES: WEST PERIMETER	DATE: 9/11/92
ELEVATION: 322.0	GWL DEPTH: DATE:	DATE STARTED: 9/11/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/14/92
DRILLING METHODS: 6" OD HSA; CONTINUOUS 5 FT SAMPLER		PAGE 4 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
90			4.5	Grades to fine to medium grained dark brown SAND, trace coarse grained, medium dense to dense, wet-saturated. Trace clay in sand at 93 ft.	sp		Beach sand.
				Brown sandy SILT, blocky, moist, stiff.	ml		
95				Brown silty fine grained SAND, trace medium grained, wet-saturated, medium dense.	sm		
				Drilled to total depth = 95 ft. Split-spoon sample to 96.5 ft.			
100							
105							
110							
115							
120							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

MWBP-11C/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-12	COORDINATES: SOUTH PERIMETER	DATE: 9/21/92
ELEVATION: 320.8	GWL DEPTH: DATE:	DATE STARTED: 9/21/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/22/92
DRILLING METHODS: 12" OD; 8 - 1/4" ID HSA; 2 FT SPLIT SPOON SAMPLING		PAGE 1 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
0					sm		
			0.5	Gravel fill with brown silty SAND.			
5			1.5	Brown silty SAND, cemented, fine and medium grained sand.			
			2	Grades to brown clayey SAND, slightly moist, low plasticity, fine grained sand.			
10			1	Gray and brown clayey sand.	sc		
			2	Brown silty SAND, fine and medium grained, loose to medium dense, some cemented nodules, slightly moist.	sm		
15			1.9	Coarse SAND seam (gray) from 16 to 16.5 ft.			
			2	Predominantly SAND, trace silt, fine and medium grained.			
20			2	Grades to lighter reddish brown fine grained SAND obvious cementation, dry.			
			2	Reddish brown fine and medium grained SAND, loose.	sp/ sm		
25			2	Grades to predominantly medium grained SAND with fine and coarse grained, trace quartz gravel.			
				Thin silty SAND with trace clay from 28 to 28.3 ft. Reddish brown silty SAND, fine grained sand, 30% silt, some cemented nodules, dry.	sm		
30							

NOTES:

Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-12	COORDINATES: SOUTH PERIMETER	DATE: 9/21/92
ELEVATION: 320.8	GWL DEPTH: DATE:	DATE STARTED: 9/21/92
ENGINEER/GEOLOGIST: S. LOGAN	GWL DEPTH: DATE:	DATE COMPLETED: 9/22/92
DRILLING METHODS: 12" OD; 8 - 1/4" ID HSA; 2 FT SPLIT SPOON SAMPLING		PAGE 2 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
30			2	Decreasing silt content, predominantly fine grained with some medium grained SAND, loose.	sp		
			2	Grade to grayish brown medium grained SAND from 33 to 33.5 ft.			
35			2	Reddish brown silty SAND with black organic nodules interspersed, dense, dry. Grades to grayish brown silty SAND, some cementation in layers, fine grained sand.	sm		
			1.5	Continued cementation in layers.			
40			1.7	Gray SILT, trace sand, stiff, dry.	ml		
				Gray SAND, fine grained, medium dense.	sp		
			2	Thin silt beds interspersed from 43 - 44 ft.			
45			2	Trace clay at 45 ft. Grades to reddish/orangish brown. Fine to coarse grained sands at 46.5 ft.			
			1.2	Grades to medium and fine grained SAND with trace silt at 48.5 ft., slightly moist.	sp		
50			2				
			2	Gray sandy SILT/SILT, interbedded layers of fine and medium grained sandy silt, blocky structure, dry.	ml		
55			1.5	Brown fine and medium grained SAND, trace silt, loose, dry.	sp		
			2	Reddish brown silty SAND, 30-40% silt, fine grained sand, trace medium grained, trace clay in spots, very loose, dry.	sm		
60							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

IT INTERNATIONAL TECHNOLOGY CORPORATION

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-12	COORDINATES: SOUTH PERIMETER	DATE: 9/21/92
ELEVATION: 320.8	GWL DEPTH: DATE:	DATE STARTED: 9/21/92
ENGINEER/GEOLOGIST: S. LOGAN/K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/22/92
DRILLING METHODS: 12" OD; 8 - 1/4" ID HSA; 2 FT SPLIT SPOON SAMPLING		PAGE 3 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
60			2	Mottled reddish brown and gray brown silty SAND, trace clay 60-60.5 ft., fine and medium grained sand, very loose, slightly moist.	sm		
			1	Gray fine grained silty SAND, trace clay at 63 ft., moist, loose.			
65				Silty CLAY, trace sand, light brown, low to medium plasticity.	cl		
			1.8	Gray and light brown SILT, trace fine grained sand, blocky structure, dry.	ml		Extremely high dry strength = soluble cement
			1.5	Grades to gray with brown mottling, sandy SILT, trace clay, fine grained sand, stiff, dry.			
70			1.8	Brown clayey SAND, fine grained sand, moist, grades to gray and light brown fine grained silty sand, moist.	sc		72.5' Ken Loy begins logging
			1.75	Gray brown silty SAND with brown mottling, fine grained, dense, moist, laminated, micaceous.	sm		
75			1	Grades to gray brown sandy SILT with reddish brown mottling, fine grained sand, stiff, moist, micaceous, trace fine grained black organic particles.			
			2	Very moist at 78 ft. (fine sand lens, wet at 78.5 ft. - 79 ft.).			∇ Perched or capillary water 10:20, 11/22/92
80			2	Gray brown sandy SILT with brown mottling, fine grained sand, firm, very moist, 1" lens, medium grained sand, brown organic particles (trace).	ml		
			1.75	Gray SILT with trace fine grained sand, firm, very moist, blocky structure.	ml		
85			2	Gray brown silty SAND, fine to medium grained, loose, wet.	sm		∇ Groundwater first observed 11:40, 9/22/92
90							Geotechnical sample 90' - 91.5'

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

MWBP-12B/FANG/drw/mb/6/21/93

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 409724	PROJECT NAME: FRESNO ANG	
BORING NUMBER: MWBP-12	COORDINATES: SOUTH PERIMETER	DATE: 9/21/92
ELEVATION: 320.8	GWL DEPTH: DATE:	DATE STARTED: 9/21/92
ENGINEER/GEOLOGIST: S. LOGAN/K. LOY	GWL DEPTH: DATE:	DATE COMPLETED: 9/22/92
DRILLING METHODS: 12" OD; 8 - 1/4" ID HSA; 2 FT SPLIT SPOON SAMPLING		PAGE 4 OF 4

Depth (ft)	Sample Type and No.	Blows On Sampler Per (NA)	Recovery (ft)	DESCRIPTION	USCS SYMBOL	HNu (ppm) & Time	REMARKS
90							
				Gray brown SILT with trace fine sand, firm, wet, mottled, with trace organic particles.	ml		
				Total Depth = 93 ft.			
95							
100							
105							
110							
115							
120							

NOTES:
Drilling Contractor: Spectrum Exploration, Inc.
Driller: Van Leonard
Helper: Tony Buckman

INTERNATIONAL TECHNOLOGY CORPORATION

MWBP-12C/FANG/drw/mb/6/21/93

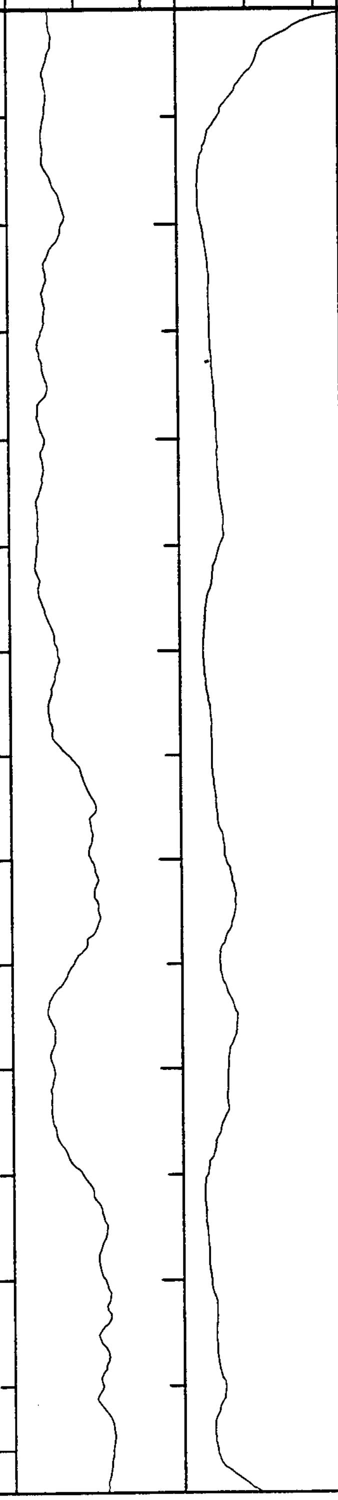
SOIL BORING EXB-01

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 252 ft.
COORDINATES: N. 2,163,669
E. 6,353,388
DATE BEGAN 10-5-93
DATE FINISHED 10-8-93
GROUND SURFACE ELEV. 324.7

DEPTH IN FEET | ELEVATION IN FEET | SAMPLE TYPE & NUMBER | RECOVERY/DRIVE (ft.) | NATURAL GAMMA (API) 0 100 200 | RESISTIVITY (ohm-meter) 0 100 | USCS | PROFILE | DESCRIPTION

Depth / Elevation: 0 – 324.7; 5 – 319.7; 10 – 314.7; 15 – 309.7; 20 – 304.7; 25 – 299.7; 30 – 294.7; 35 – 289.7; 40 – 284.7; 45 – 279.7; 50 – 274.7; 55 – 269.7; 60 – 264.7; 65 – 259.7; 70 – 254.7

Sample: DB-46.5
Recovery: NR



USCS	DESCRIPTION	Depth
sm	SAND WITH SILT; gray orange; very soft; <10% silt; dry.	2.0'
sp	SAND; dark yellow brown; medium sand, moist, silt <10%, moist.	5.0'
sm	SILTY SAND; minor clay; dark brown; slightly moist; hard; medium sand; silt to 30%.	8.0'
sm	SILTY SAND; grayish red; hard light olive gray; slightly moist.	11.0'
ml	SANDY SILT; moderate yellow brown; firm; nonplastic; slightly moist. Slightly plastic at 15 ft. Some clay at 15 ft.	17.0'
sm	SILTY SAND; moderate brown; firm; silt 30%; moist; micaceous; medium sand. Firm, but platy, coarse sand at 20 ft. with 40% silt; firm, fine sand. Some clay. Silt 20% at 25 ft. Medium sand.	25.0'
ml	CLAYEY SANDY SILT; olive gray; fine sand; moist; very slight plasticity.	28.0'
sm	SILTY SAND; moderate brown; 40% silt; non-plastic; fine to very fine sand.	30.0'
ml	CLAYEY SILT; moderate red brown; moist; slightly plastic; very fine sand; <5% firm.	32.0'
sm	SILTY SAND; moderate yellow brown; hard; medium sand; silt 20-30%; moist.	35.0'
ml	SANDY SILT; grayish brown; moist; hard; nonplastic; fine sand <10%; light brown at 37 ft.; some gray mottle; very fine sand at 38 ft.	39.0'
sm	SILTY SAND; light brown; stiff, silt 20%; sand medium to coarser; slightly moist; minor very coarse sand.	39.5'
sw	SAND; light brown to moderate yellow brown; very coarse sand; clean at 40 ft.; soft; silt 30% at 41 ft.; <5% below; some fine gravel <<1%.	45.5'
cl	SILTY CLAY; light olive gray; soft; medium plasticity; moist; red mottle.	46.5'
sm	SILTY SAND; light olive gray with light brown streaks; fine sand; silt 35%; medium hard; slightly moist; <5% silt at 48 ft.; medium sand at 48 ft.; medium yellow brown at 48 ft.; sand coarse at 50 ft.; silt >40% at 51 ft.	51.5'
sp	SAND; light olive gray to pale yellow brown; medium sand; slightly moist; poorly graded; some silt; generally <5%; some thin layers >15%; increasing silt with depth to 40% at base.	56.0'
ml	SILT; moderate yellow brown with pale olive mottle; hard to very hard; slightly moist; non-plastic.	57.0'
cl	SILTY CLAY; moderately brown; moist; hard; medium plastic; minimum or very fine sand <1%.	57.5'
ml	SILT; pale yellow; slightly moist; soft; light brown mottle. very fine sand <1%. Yellowish gray at 61 ft.; very slightly plastic; minor clay <1%; non plastic below 63 ft.	64.0'
ml	CLAYEY SILT; pale yellow brown; moist; plastic to slightly plastic; soft but crumbly. Pale olive at 68 ft.	70.0'

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: North perimeter field
PROJECT NO.: 409724

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

EXB01-el(FA001)

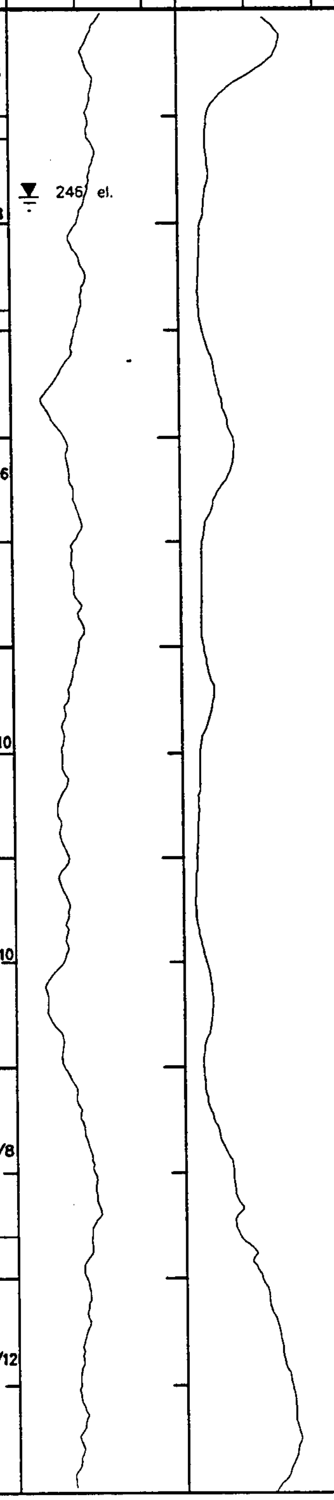
SOIL BORING EXB-01

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 252 ft.

COORDINATES: N. 2,163,669
E. 6,353,388
DATE BEGAN 10-5-93
DATE FINISHED 10-8-93
GROUND SURFACE ELEV. 324.7

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)
70	254.7	EXB01-70	
75	249.7		5/8
80	244.7		10.8/8
85	239.7		
90	234.7		18/16
95	229.7		
100	224.7		
105	219.7		15/10
110	214.7		
115	209.7		17/10
120	204.7	EXB01-122	
125	199.7		13/8
130	194.7		
135	189.7		13/12
140	184.7		

NATURAL GAMMA (API) 0 100 200 — RESISTIVITY (ohm-meter) 0 100



USCS	DESCRIPTION	Bottom depth
sp	SAND; grayish orange; slightly moist; medium sand; slightly coarser below 72 ft.; poorly graded; subangular to angular grains.	76.0'
ml	CLAYEY SILT; light olive gray; moist; slightly plastic, mottled with dark yellow-orange; firm.	86.0'
ml	SANDY SILT; light olive gray; wet; medium sand 30%; non plastic; soft.	91.0'
sp	SAND; moderate brown; very soft; poorly sorted coarse sand; clean sand; wet.	95.0'
ml	SILT; light olive gray; slightly plastic; very moist; medium-fine sand 10%; some clay; soft.	98.0'
cl	CLAYEY SILT; pale yellow brown; moist to wet; plastic; soft; crumbly below 98 ft.	102.0'
sp	SAND; light olive gray; wet; medium sand; micaceous; soft.	105.0'
ml	SANDY SILT; moderate yellow brown; moist; firm; slightly plastic.	106.0'
cl	SILTY CLAY; light brown; moist; plastic; firm.	107.0'
ml	SILT with SAND; medium yellow brown; soft; wet; medium sand 15%; slightly plastic; micaceous.	110.0'
sp	SAND; light olive gray; wet; fine sand; very soft.	113.0'
ml	SILT with SAND; moderate yellow brown; moist; slightly plastic; soft; some clay content; fine sands <10%. Decrease in plasticity.	117.0'
	Hard pan; light gray; very hard; cemented clay.	
sm	SAND with SILT; light brown; very moist; silt 10-20%; fine sand; firm.	120.0'
ml	SILT; light brown; moist; non-plastic; sand 10%; fine to medium; very hard. Soft at base.	123.0'
sm	SILTY SAND; moderate yellow brown; very moist; silt up to 40%; very slight plasticity; soft.	128.0'
sm	SAND with SILT; moderate yellow brown; wet; very soft; decreasing silt content to contact; fine sand; silt content 5-10% at top of unit.	131.0'
sw	SAND; pale olive; very wet; very soft; coarse sand at top; minor silt at at top; decrease with depth. Very clean sand-very coarse at 135 ft.	140.0'

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: North perimeter field
PROJECT NO.: 409724

EXB01-el(FA001)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

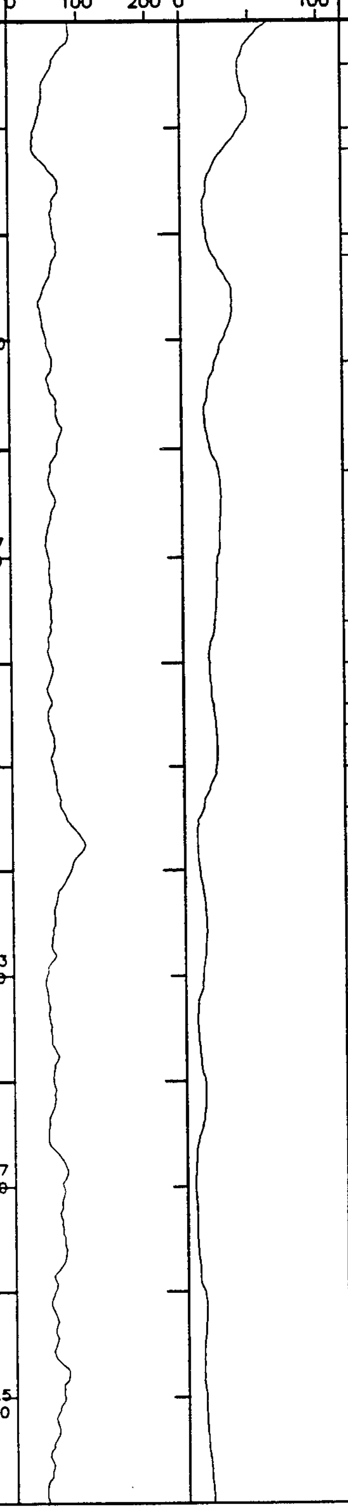
SOIL BORING EXB-01

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 252 ft.

COORDINATES: N. 2,163,669
E. 6,353,388
DATE BEGAN 10-5-93
DATE FINISHED 10-8-93
GROUND SURFACE ELEV. 324.7

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)
140	184.7		
		EXB-01 142	
145	179.7		NR
		EXB-01 148	
150	174.7		
155	169.7		12/10
160	164.7		
165	159.7		19.7/10
170	154.7		
175	149.7		NR
		EXB-01 177	
180	144.7		
185	139.7		13.3/10
190	134.7		
195	129.7		11.7/10
200	124.7		
		EXB-01 203	
205	119.7		13.5/10
210	114.7		

NATURAL GAMMA (API) 0 100 200 — RESISTIVITY (ohm-meter) 0 100



USCS	DESCRIPTION	
sm	SILTY SAND; moderate yellow brown; moist; firm; fine to medium sand; silt 30%.	142.0'
sp	SAND; light olive gray; wet; very soft; coarse sand; no silt.	145.0'
sm	SILTY SAND; medium yellow brown; firm; moist; silt 30%; fine sand.	146.0'
sm	SILT with SAND; moderate brown; very moist; firm; slightly plastic; sand 20%; fine at top; increasing size with depth.	150.0'
sm	SILTY SAND; medium yellow brown; very moist; soft; fine sand; silt 20%.	151.0'
sp	SAND WITH SILT; moderate yellow brown; very moist; very soft; medium sand, sub-rounded; silt >5%.	156.0'
ml	SILT; moderate brown; moist; very hard; non-plastic; fine sand <5%; increased sand at 158 ft.; slightly softer; sand decrease to <1% at 159 ft.	161.0'
sw	SILTY SAND; moderate yellow brown; firm to slightly hard; fine sand; moist; 30-40% silt. medium to coarse sand; silt 20-30%; some cobbles. fine sand; some medium to coarse; silt 20%. silt increases to 40%; very firm. firm; silt 10-20%.	168.0'
ml	SANDY SILT; moderate yellow brown; very hard; slightly moist; very slightly plastic; sand very fine; 5%.	170.0'
sm	SAND; light olive gray; mottled with medium yellow brown; soft; very wet.	172.0'
ml	SILT; light brown; fine sand <1%; moist; non-plastic; soft.	173.0'
sm	SAND with SILT; light brown; moist; soft; silt 10% non-plastic.	175.0'
sp	SAND; dark yellow brown; coarse sand; moist; very soft.	177.0'
cl	CLAY; greenish gray; very slightly moist; very hard; plastic; carbon clasts; 3-4mm.; some very fine sand <1% and silt <1%.	181.0'
sm	SILTY SAND; moderate yellow brown; slightly moist; very-very hard; nearly consolidated; 10-20% silt; coarse to very coarse sand; some very fine gravel <1%.	187.0'
ml	SILT to CLAYEY SILT; pale yellow brown; dry to slightly moist; increasing plasticity; very hard with depth; non-plastic at top-slight plastic at base.	190.0'
sp	SAND; moderate olive brown; with very dark red streaks horizontal; micaceous; moist; firm; medium sand.	192.0'
ml/cl	CLAYEY SILT; pale yellow brown; very slightly moist; light brown mottle; very hard; very difficult to hydrate; slightly plastic to plastic. Some fine sand near 200 ft. <5% graduational contact.	200.0'
sm	SAND with SILT; pale brown; very moist; very soft; medium sand; silt; (5%-10%)	203.0'
ml	SILT; moderate brown; slightly moist to dry; very hard; coarse sand, very coarse sand and small gravel <1%; laminated; very slight plastic; sand <5%. -plastic at 207 ft. -non-plastic at 208 ft.	

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: North perimeter field
PROJECT NO.: 409724

EXB01-el(FA001)

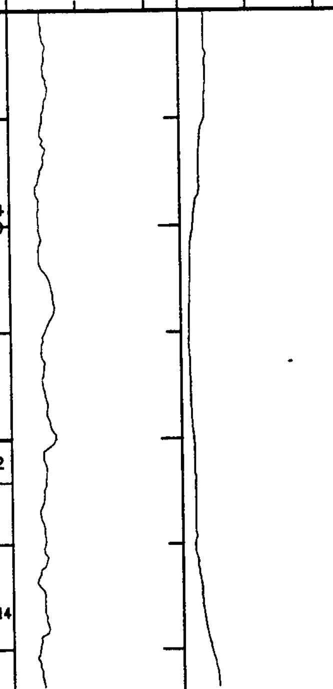
SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-01

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 252 ft.
COORDINATES: N. 2,163,669 E. 6,353,388
DATE BEGAN 10-5-93
DATE FINISHED 10-8-93
GROUND SURFACE ELEV. 324.7

NATURAL GAMMA (API) 0 100 200 — RESISTIVITY (ohm-meter) 0 100



DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)	USCS	DESCRIPTION
210	114.7			ml	SILT with SAND; light brown; very moist; very soft; medium sand 10-20%; very slightly plastic. 212.0'
				sm	SILTY SAND; moderate brown; very moist; medium sand; soft; silt 10-15% Silt to 25% at 214 ft.; fine sand only. Silt <10% at 215 ft.; medium and fine sand. 216.0'
215	109.7	EB-01 216			
220	104.7		19.4/20	ml	SILT; moderately yellow brown; fine sand <5%; as low as 1%; minor coarse sand <<1%; very hard; dry to very slightly moist. Very coarse sand 5% at 224 ft. 225.0'
225	99.7			ml	SILT; moderate brown; dry to very slightly moist; very slightly plastic; very hard; coarse to very coarse sand <1% zoned. 228.0'
				sw	SILTY SAND; dark yellow brown; dry to very slightly moist; very hard; (almost consolidation); coarse to fine sand; silt to 10%; very clear sand; 10-30%; occasional small pebble; some zonation of sand; very slightly silt within core. 230.0'
230	94.7		1/2	ml	SILT; moderate red orange; moist; hard; non-plastic; random medium sand and decayed mafic clasts <1%; vertical manganese track; some gray mottle. 234.0'
235	89.7			ml	SANDY SILT; moderate red orange; moist; non-plastic; medium sand 30%; coarse sand 5%; very coarse <5%. 238.0'
240	84.7		25/14	sw	SILTY SAND; light brown; slightly moist; hard to very hard; sand-medium to coarse; very coarse 5%; silt 30-40%; subrounded. 242.0'
		EB-01 243		sm	SILTY SAND; brownish gray; very moist; very soft; medium to very coarse sand; blue silt; clasts. 243.0'
245	79.7	EB-01 247		sw	SAND; medium yellow brown; very wet; very soft; coarse to very coarse; sand 90% fine to medium gravel <5%; silt <1%; decayed blue-green medium gravel <1%; medium sand at 247 ft.- no silt; very wet; silt clay stringers; minor blue clay clasts; very coarse sand at base; very clear silt rounded; occasional large gravel clast. 249.0'
250	74.7		12/6	sm/ml	SILTY SAND-SANDY SILT; medium yellow brown; medium sand 50%; silt 50%; firm; very moist; very firm; clay at 250 ft.; slight to medium plastic; sand 20%; fine.
					TOTAL DEPTH 252 FEET
255	69.7				
260	64.7				
265	59.7				
270	54.7				
275	49.7				
280	45.7				

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: North perimeter field
PROJECT NO.: 409724

EXB01-el(FA001)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

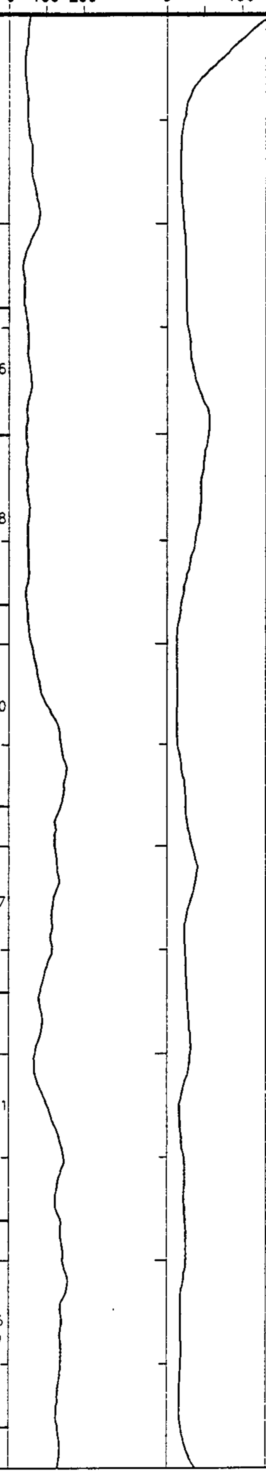
INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-02

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 255 ft.

COORDINATES: N. 2,163,424 E. 6,353,050
DATE BEGAN 10-11-93
DATE FINISHED 10-14-93
GROUND SURFACE ELEV. 324.2

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)	NATURAL GAMMA (API) 0 100 200 / RESISTIVITY (ohm-meter) 0 100	P.I.D. READING (ppm)	USCS	PROFILE	DESCRIPTION
0	324.2					ml		SILT; yellow brown; very dry; very soft. 4.0'
5	319.2					sp		SAND; moderate yellow; slightly moist; very soft; fine sand. 6.0'
						ml		SILT; dark yellow orange; dry to slightly moist; soft; non-plastic; fine sand <5%; hard (moderately) at 8 ft.; some clay at 9 ft. 9.0'
10	314.2					ml		SILT; dark yellow brown; very moist; slightly plastic; soft; very fine sand <10%. 12.0'
15	309.2					sm		SILTY SAND; dark yellow orange; moist; firm sand (fine); silt 20%; micaceous; medium sand at 13 ft. 16.5'
			8.9/6			sp		SAND; dark yellow brown; moist; soft; medium sand; silt <5%. 21.0'
20	304.2					sm		SILTY SAND; moderate brown; moist; medium sand; silt 20%; soft. Silt 15%. Dark yellow brown silt <5%. Silt 20%; light brown. 28.5'
25	299.2		6.9/8					
30	294.2		20/10			sm		SILTY SAND; light brown; very firm; moist; silt to 30-40%; minor clay. Minor clay. 36.0'
35	289.2					ml		CLAYEY SILT; mottled; pale yellow brown and light brown; moist; very slightly plastic; soft. 37.5'
						ml		SILT; moderate yellow brown; moist; slightly firm; blocky; non-plastic; very fine sand <5%. 39.0'
40	284.2	EXB02-40				sw		SAND; gray orange; very soft; very moist; coarse to very coarse sand; poorly graded. 40.0'
			16/7			ml		SILT; pale yellow brown; very moist; soft; minor very fine sand. Platey near base. 43.0'
45	279.2					sw		SAND; dark yellow orange; moist to dry; soft to slightly hard; layered; poorly sorted; fine to coarse. 47.0'
						ml		SILT; dark yellow brown; moist; slightly hard; fine sand <5%. 48.5'
50	274.2					sp		SILTY SAND; moderate yellow brown; moist; soft with hard layers; silt 20%; fine sand; coarse sand at 50 ft.; silt <5%; very fine sand; silt 30% at base. 51.0'
			18/11			sp		SAND; pale orange; slightly moist to dry; very soft medium sand; moderate yellow brown at base (6"). 53.0'
55	269.2					ml		SILT; light brown; very slightly moist; very hard; non-plastic; very fine sand <1%; platy core. 56.0'
60	264.2					ml/cl		CLAYEY SILT; pale yellow brown; moist to slightly moist; very soft; medium plastic; moist at top; dry below. Increased silt at 58 ft.; very slightly plastic; dry. Decreased silt at 60 ft.; increase to plastic. 62.0'
			17.5/10			sp		SAND; light brown; medium grain; moist; poorly sorted; very soft. A very pale orange; medium-fine at 63 ft.; well sorted. 64.0'
65	259.2					cl		SILTY CLAY; light olive gray; very moist; soft; plastic; brown mottle at 64-65 ft.
70	254.2							



DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: North perimeter field
PROJECT NO.: 409724

40972401 04/17/96 2:26pm D.Billingsley

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

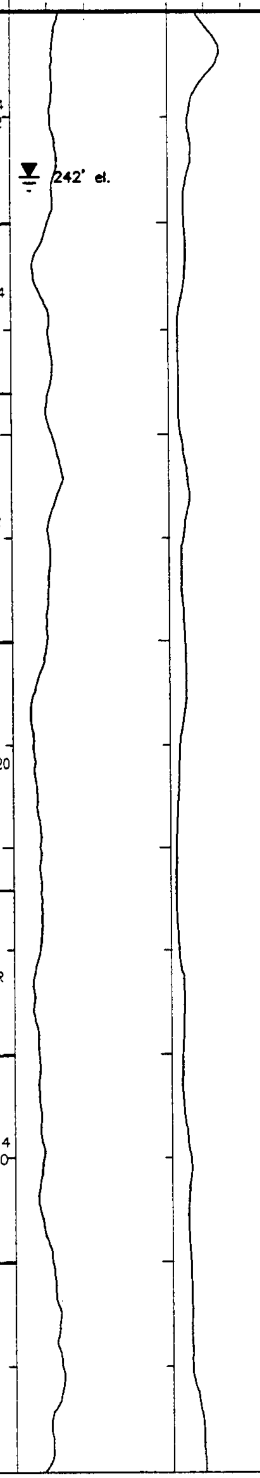
SOIL BORING EXB-02

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 255 ft.

COORDINATES: N 2,163,424
E 6,353,050
DATE BEGAN 10-11-93
DATE FINISHED 10-14-93
GROUND SURFACE ELEV. 324.2

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)
70	254.2		
75	249.2		15.4 /12
80	244.2		
85	239.2	EXB02-85	10.4 /8
90	234.2		
95	229.2		NR
100	224.2	EXB02-101	
105	219.2		25/20
110	214.2		
115	209.2		NR
120	204.2		
125	199.2	EXB02-125	18.4 /10
130	194.2	EXB02-132	
135	189.2		
140	184.2		

NATURAL GAMMA (API) 0 100 200 — RESISTIVITY (ohm-meter) 0 100 — P.I.D. READING (ppm)



USCS	DESCRIPTION	
cl	Moist; crumbly.	71.0'
sp	SAND; (very clean); pale yellow brown; moist; poorly graded; very soft. Pale yellow orange. Fine sand near base (very clean).	76.0'
ml	CLAYEY SILT; pale yellow brown; with light brown mottle; slightly plastic; moist; slightly hard.	79.0'
sp	SAND WITH SILT; moderate yellow brown; moist; firm; fine to very fine sand; <5%	81.0'
ml	CLAYEY SILT; pale yellow brown with light red mottle; very moist; slightly plastic.	83.0'
sp	SAND; moderate yellow brown; wet; very soft; medium sand; <1% silt; poorly sorted.	85.0'
ml	SILT WITH CLAY; pale olive gray; moist; very slightly plastic; firm. Sand zone at 88 ft.; sand ≈ 40%.	89.0'
cl	CLAY; pale olive gray; very moist; plastic to very plastic; soft.	90.0'
sm	SILTY SAND; sandy silt with possible medium sand layers ≈ 1 ft. thick; medium yellow brown; soft to hard; very moist.	100.0'
sm	SAND with SILT; pale yellow brown; very moist; very soft; very fine sand; silt <10%	101.0'
ml	SILT; pale yellow brown; moist; firm.	102.0'
sm	SAND WITH SILT; light olive gray; very moist; soft; medium sand; <5% silt.	105.0'
ml	SANDY CLAYEY SILT; medium yellow brown; moist; slightly hard; slightly plastic; medium to coarse sand <5%.	115.5'
ml	SILT; moderate brown; moist; hard; medium sand 10%; non-plastic.	118.0'
sm	SAND with SILT; moderate brown; moist; hard; medium sand; silt 10%	121.0'
ml	SILT with SAND; moderate yellow brown; moist; hard; medium sand (20%); slightly plastic.	122.0'
ml	SILT; light brown; very slightly moist; very hard; very coarse to medium sand; 10% non plastic. Very hard.	127.0'
sm	SILTY SAND; moderate yellow brown; medium sand; moist; hard but friable; silt 20%.	129.0'
sm	SANDY SILT; moderate brown; hard; medium to very moist; non plastic; medium sand 40%.	130.0'
sp	SAND; moderate brown; wet; very soft; dense sand; very soft. medium sand 40%.	133.0'
cl	SILTY CLAY; light brown; very moist; plastic; very soft.	135.0'
ml	SANDY SILT; light brown; very moist; slightly plastic; (some clay); very soft.	137.5'
ml	SILT; moderate brown; very moist; very soft; non plastic.	139.0'
sp	See next sheet.	

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: North perimeter field
PROJECT NO.: 409724

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

40972402 04/17/96 2:33pm D.Billingsley

SOIL BORING EXB-02

FIELD GEOLOGIST T. Ault — COORDINATES: N. 2,163,424 E. 6,353,050
CHECKED BY T. Ault — DATE BEGAN 10-11-93
APPROVED BY S. Logan — DATE FINISHED 10-14-93
TOTAL DEPTH 255 ft. — GROUND SURFACE ELEV. 324.2

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)	USCS	DESCRIPTION
140	184.2			sp	SILTY SAND; pale yellow brown; very moist; very soft; silt <5%. Silt increased at 140 ft. 30%. 141.0'
				sp	SAND; light olive gray; very moist; very soft; medium sand; possible clay fraction. 145.0'
145	179.2	DB02-145	25/30	ml	SILT; moderate yellow brown; moist; firm; slightly plastic. 148.0'
150	174.2	DB02-152, DB02-154		sm	SAND WITH SILT; moderate yellow brown; very soft; very wet; medium sand; silt <5% below 148 ft.; 20 to 30% above (147-148 ft.). Coarse sand; no silt. 154.0'
155	169.2		25/10	ml	SANDY SILT; moderate yellow brown; very moist; soft; medium sand; 20-30%; very coarse sand 5%. 157.0'
				sm	SILTY SAND; moderate yellow brown; very moist; soft; medium sand; 20-30%. 159.0'
160	164.2			ml	SANDY SILT; light brown; moist; hard; fine sand 5%. Moderate brown; sand increase to 20%; fine sand; very moist. 167.0'
165	159.2		20/15		SANDY SILT 30-40%; medium sand with minor coarse to very coarse sand. 174.0'
170	154.2				
175	149.2			sm	SAND with SILT; moderate yellow brown; moist; hard; medium to coarse sand; minor very coarse sand at top; silt 10% decreases with depth. 175.5'
				sp	SAND; light to pale brown; very moist; increasing silt with depth; hard at base. 177.0'
		EXB02-180		ml	SILT WITH SAND; light brown; moist; firm; slightly plastic; medium to fine sand 5%. 180.0'
180	144.2		13/10	sm	SILTY SAND; light brown; very moist; very soft; medium sand; silt 20%. 182.0'
				ml	SANDY SILT; pale olive brown; moist; firm to hard; platy; non-plastic; medium to coarse sand, 30%. 186.0'
185	139.2			sm	SILTY SAND; light brown; slightly moist; very hard; medium to coarse sand; medium 40%; coarse 30%; very coarse 5-10%; silt up to 20%. 190.0'
190	134.2		5/10	ml	SILT; moderate yellow brown; hard; fine sand <5%; very slightly plastic; very thin lamina of medium sand at 1-2 ft. intervals. 195.0'
195	129.2			ml	SILT; light brown; moist; hard; medium sand <5%. Very hard-dry medium sand-coarse sand 5%. Very hard.
200	124.2		21/20		
205	119.2				Slightly plastic to medium plastic. Very slightly plastic.
210	114.2				

Log columns also include: NATURAL GAMMA (API) 0 100 200; RESISTIVITY (ohm-meter) 0 100; P.I.D. READING (ppm); PROFILE.

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: North perimeter field
PROJECT NO.: 409724

40972403 04/17/96 2:43pm D.Billingsley

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-02

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 255 ft.

COORDINATES: N. 2,163,424
E. 6,353,050
DATE BEGAN 10-11-93
DATE FINISHED 10-14-93
GROUND SURFACE ELEV. 324.2

DEPTH IN FEET	ELEVATION IN FEET
210	114.2
215	109.2
220	104.2
225	99.2
230	94.2
235	89.2
240	84.2
245	79.2
250	74.2
255	69.2
260	64.2
265	59.2
270	54.2
275	49.2
280	44.2

SAMPLE TYPE & NUMBER: EXB-02 220; EXB-02 238; EXB-02 248

RECOVERY/DRIVE (ft.): 4 7/3; 14/12; 13/10; NP; 19/10

NATURAL GAMMA (API): 0 100 200
RESISTIVITY (ohm-meter): 0 100
P.I.D READING (ppm)

USCS	DESCRIPTION	Bottom
ml	Very very hard; medium yellow brown. Very slightly plastic. Coarse to very coarse sand <10%. Soft at 215 ft.; fine sand <5%; thin dark yellow brown; slightly clayey. Hard at 217 ft. Fine sand <1%	221.0'
ml	SILT with SAND; very hard; light brown; very slightly moist; coarse sand 5% very coarse sand 1%. coarse sand 20%; very coarse 5%	228.5'
ml	CLAYEY SANDY SILT; pale brown; very very hard; very slightly moist; very coarse sand 5%	231.0'
ml	SANDY SILT; light brown; moist; very hard; extremely fine sand <10%; very coarse sand <5%; rare very fragmented decomposed mafics; slightly moderate plastic; some clays. Coarse sand content decreasing with depth. Very fine sand only 10–15%. Soft with very fine sand only at 240 ft.	241.0'
sm	SILTY SAND; moderate yellow brown; very moist; fine 20 to 30%; silt; some clay.	244.0'
ml	CLAYEY SILT WITH SAND; grayish orange pink to medium yellow brown; mottled/segregated; very fine sand <5%; very hard.	246.0'
sm	SILTY SAND; pale red to light brown; slightly moist; very hard; mixed ground mass; coarse; very coarse sand; small gravel; silt 10% or less. Coarse sand predominant at 248 ft. Medium sand at base.	249.0'
cl	SILTY CLAY; light brown; moderate slightly moist; very hard; medium plastic.	

TOTAL DEPTH 253 FEET

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: North perimeter field
PROJECT NO.: 409724

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

IT INTERNATIONAL TECHNOLOGY CORPORATION

40972405 04/17/96 2:55pm D.Billingsley

SOIL BORING EXB-03

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 255 ft.

COORDINATES: N. 2,163,113
E. 6,352,668
DATE BEGAN 10-15-93
DATE FINISHED 10-17-93
GROUND SURFACE ELEV. 323.6

DEPTH IN FEET	ELEVATION IN FEET
0	323.6
5	318.6
10	313.6
15	308.6
20	303.6
25	298.6
30	293.6
35	288.6
40	283.6
45	278.6
50	273.6
55	268.6
60	263.6
65	258.6
70	253.6

SAMPLE TYPE & NUMBER: EXB03-34 (at approx. 34 ft)

RECOVERY/DRIVE (ft.): 13/8; 6/5; 10/15; 12/6; 12/7; 10/10; 19/20

DRILLING REMARKS | P.I.D. READING (ppm)

USCS	DESCRIPTION	DEPTH
ml	SANDY SILT; pale brown; dry to slightly moist; soft; non-plastic; 20% fine sand.	4.0'
sp	SAND; dark yellow brown; slightly firm; medium sand. Light brown below 6 ft.	8.0'
ml	SILT; gray-orange; very to slightly moist; soft; non-plastic; very fine sand <1%.	12.0'
cl	CLAY; pale yellow brown; slightly moist; firm; medium plastic.	13.0'
sp	SAND; pale yellow brown; moist; very soft; medium sand (poorly graded) uniform. Silt/Clay content increase, very fine sand. No silt/clay medium sand.	20.0'
sw	SAND; dark yellow orange; moist; very soft; well graded; medium to very coarse sand; 40% medium sand; 40% coarse sand; 10% very coarse. 10% fine gravel. Increase in fines, 10% silt.	25.0'
sp	SILTY SAND; light brown; moist; soft; 20% medium sand.	28.0'
sp	SAND; dark to yellow orange; moist; very soft; poorly graded sand; 10% fine; 30% medium; 50% coarse; 20% very coarse.	32.0'
sp	SAND; light brown; very moist; very soft; 80% medium sand; 5% coarse sand; 5% silt. Light brown, very coarse sand only.	34.5'
ml	SILT WITH CLAY; moderate yellow brown; very moist; soft; very slightly plastic, very fine sand <1%.	36.0'
sm	SILTY SAND; moderate yellow brown; moist; slightly firm; fine to medium sand; 40-45% silt.	38.0'
sp	SAND; pale yellow brown; moist; very soft; medium to fine sand; poorly graded.	39.5'
ml	SANDY SILT; pale yellow brown; moist; slightly hard; slightly plastic; very fine sand <15%.	41.5'
sp	SAND; light olive gray; very moist; very soft; coarse sand (poorly graded).	43.0'
cl	CLAY WITH SILT; pale yellow brown; moist to very moist; soft; slightly to medium plastic.	45.0'
ml	SANDY SILT; light brown to pale yellow brown; moist; very firm, non-plastic; fine to very fine sand; 5-10% fine sand.	46.0'
sw	SAND; pale yellow brown; dry; very soft; medium to very coarse, well graded.	49.0'
sm	SILTY SAND; light olive gray; moist; hard; 50% medium sand; 30% fine sand; 20% silt.	51.5'
sw	SAND; pale yellow brown; moist; very soft. (51.5 FT.) 5% silt upper 1 ft., medium to very coarse sand. (52.5 FT.) No silt, no fines clean sand. Olive gray, medium sand.	60.0'
ml	SANDY SILT; moderate yellow brown; very moist; firm; very to slightly plastic; some fine gravel; 5-10% coarse to very coarse sand.	69.5'

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Rotasonic
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: Site 5
PROJECT NO.: 409724

EXB03(FA002)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-03

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 255 ft.
COORDINATES: N. 2,163,113
E. 6,352,668
DATE BEGAN 10-15-93
DATE FINISHED 10-17-93
GROUND SURFACE ELEV. 323.6

DEPTH IN FEET	ELEVATION IN FEET
70	253.6
75	248.6
80	243.6
85	238.6
90	233.6
95	228.6
100	223.6
105	218.6
110	213.6
115	208.6
120	203.6
125	198.6
130	193.6
135	188.6
140	183.6

SAMPLE TYPE & NUMBER: EXB03-88, EXB03-92, EXB03-97, EXB03-10, EXB03-123, EXB03-128, EXB03-134

RECOVERY/DRIVE (ft.): 12/10, 5/5, 16/15, 30/20, 15/12

DRILLING REMARKS: 243.2' el.

P.I.D. READING (ppm)

USCS	DESCRIPTION	Depth
ml	SILT; pale yellow brown with light red mottle; moist; firm; very slightly plastic.	72.0'
sm	SILTY SAND; light brown; moist; medium sand; 10-20% silt.	73.0'
sp	SAND; light brown; moist; very soft; medium sand.	76.0'
ml	SILT; light brown with gray mottle; firm to hard. Gray at base.	78.0'
sm	SILTY SAND; light olive gray; very moist; soft to firm; 20% silt. <5% silt.	80.0'
sp	SAND WITH SILT; pale yellow brown; wet; very soft; medium sand; Silt <5%. No silt.	83.0'
ml	SILT; yellowish gray; wet; firm to soft; non-plastic. Increasing sand content with depth. <5% fine sand at 85 ft.	85.5'
sp	SAND; light olive gray; very moist; soft; medium sand; clayey rind on core.	89.0'
ml	SANDY SILT;; moderate yellow brown; soft; very slightly plastic; 20% fine sand;.	92.0'
sm	SILTY SAND; light olive gray to dark yellow brown; firm; very slightly plastic; very fine sand; 45% silt.	96.0'
sp	SAND WITH SILT; pale yellow brown; very moist; soft; layered sand fine to medium; poorly graded.	98.0'
sm	SILTY SAND; pale yellow brown (with red tint); soft; very slightly plastic; very fine sand; well sorted; silt to 20%.	100.0'
ml	SILT; light olive gray; very moist; soft; slightly plastic (clayey). 20% very fine sand.	103.0'
sp	SAND; light olive gray; very moist; very soft; medium sand. Silt rind on core, wet.	105.0'
sm	SILTY SAND; light olive gray; very moist; soft; silt to 10%; fine sand. Coarse clean sand at base.	109.0'
ml	SANDY SILT; light brown; firm; slightly plastic; 10% fine sand. Some clay, very moist. Silt clasts to 1 in. 20% fine sand. White concretions. — Slight variations in plasticity throughout zone.	120.0'
sm	SILTY SAND; light brown; very moist; very soft; medium sand; silt to 40%.	122.0'
ml/sm	SANDY SILT; light brown; very moist; soft; very slightly plastic; 40% medium to coarse sand.	125.0'
ml	SANDY SILT; light brown; moist; very firm; non-plastic; 10-30% medium to very coarse sand.	129.0'
ml	SILT; moderate brown; moist; hard; non-plastic. Fine sand <1%.	132.0'
ml	CLAYEY SILT; pale yellow brown; very moist to wet; slightly firm; slightly plastic; very fine sand <1%.	138.0'
sp	SAND; light olive gray; very moist; very soft; medium sand (poorly graded).	

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Rotasonic
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: Site 5
PROJECT NO.: 409724

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

EXB03(FA002)

SOIL BORING EXB-03

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 255 ft.

COORDINATES: N. 2,163,113
E. 6,352,668
DATE BEGAN 10-15-93
DATE FINISHED 10-17-93
GROUND SURFACE ELEV. 323.6

DEPTH IN FEET	ELEVATION IN FEET
140	183.6
145	178.6
150	173.6
155	168.6
160	163.6
165	158.6
170	153.6
175	148.6
180	143.6
185	138.6
190	133.6
195	128.6
200	123.6
205	118.6
210	113.6

SAMPLE TYPE & NUMBER: EXB03-151, EXB03-175, EXB03-178, EXB03-188, EXB03-198, EXB03-208, EXB03-209

RECOVERY/DRIVE (ft.): 14/13, 25/20, nr, 20/20, 6/4

DRILLING REMARKS | P.I.D. READING (ppm)

USCS	DESCRIPTION	Bottom depth
sp	SAND; light olive gray; very moist; very soft; medium sand (poorly graded).	144.0'
ml	SILT WITH MINOR CLAY; light olive gray; slightly moist; very slightly plastic. Light brown.	150.0'
sp	SAND; moderate yellow brown; wet; very soft; fine sand. Clayey zone, very wet. Medium sand, wet, no fines.	154.0'
ml	SANDY SILT; dark yellow brown; very moist; firm; very slightly plastic; 20% fine sand. 30% medium sand.	159.0'
sp	SAND WITH SILT; olive gray; very moist; very firm; medium sand; <5% silt.	162.0'
ml	SANDY SILT; light brown; moist; hard; very slightly plastic; fine sand <5%. 5% coarse sand.	164.5'
sw	SAND WITH SILT; moderate yellow brown; very moist; soft to slightly firm; medium to coarse sand; silt content <1% to 5%.	167.0'
sm	SILTY SAND; moderate yellow brown; moist; firm; 20% sand.	169.0'
ml	SILT; light brown; slightly moist; hard; very slightly plastic.	170.0'
sp	SAND; light olive gray with moderate brown; very moist; soft; medium sand; silt <1%.	174.0'
ml/sm	SANDY SILT; light to moderate brown; moist; slightly firm; non-plastic; 30% medium sand; 5% very coarse sand.	180.0'
ml	SANDY SILT; light brown; very moist; soft; non-plastic; poorly sorted sand; 30-40% medium to very coarse sand; some very fine gravel.	186.0'
sm	SILTY SAND; olive gray (light); very moist; firm; 80% medium sand; 10% coarse; 10% silt.	191.0'
sw	SAND; pale olive brown; wet; soft to very firm; medium to coarse sand. Silt zone.	194.0'
ml	SILT; light brown; moist; hard; very slightly plastic. Medium sand zone 5" soft, wet. Medium sand zone soft, wet.	200.0'
sp	SAND; light olive gray; wet; very soft; medium sand. Coarse	203.0'
ml	SILT TO SANDY SILT; very moist; soft; very slightly plastic; coarse sand <5%.	204.0'
ml	SANDY SILT; light brown; moist; very hard; non-plastic; 5% coarse sand.	

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Rotasonic
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: Site 5
PROJECT NO.: 409724

EXB03(FA002)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-03

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 255 ft.

COORDINATES: N. 2,163,113
E. 6,352,668
DATE BEGAN 10-15-93
DATE FINISHED 10-17-93
GROUND SURFACE ELEV. 323.6

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)	DRILLING REMARKS	P.I.D. READING (ppm)	USCS	DESCRIPTION
210	113.6					ml	SANDY SILT; light brown; moist; very hard; non-plastic; 5% coarse sand.
							SANDY SILT; light olive; very moist; hard; 20% medium sand. 213.5'
						sp	SAND; light olive gray; medium sand. 214.0'
215	108.6		26/15				SANDY SILT; light brown; wet; very firm; slightly plastic (some clay); 20% medium sand. 217.0'
							SANDY SILT; light brown; very hard; non-plastic; 10% medium sand.
220	103.6						Very slightly plastic, very fine sand. 221.0'
							SILT; moderate yellow brown; dry; very very hard; plastic (upper 2 ft.).
							Non-plastic.
225	98.6		18/13				
							Fine sand (very) <1%.
230	93.6					ml	5-10% coarse sand. 235.0'
235	88.6						SILT; light brown to pale brown; dry to slightly moist; very very hard; non-plastic. 239.0'
			15/8				
240	83.6	EXB03-241					SANDY SILT; grayish orange; dry; very hard; non-plastic; very fine to fine gravel <1%; fine sand <5%; occasional large gravel clast 1-2 in..
			NR				
245	78.6						Medium sand <5%. 245.0'
							SANDY SILT (WITH SOME CLAY); moderate yellow brown; very wet; very soft; slightly plastic; 10% medium to fine sand; fine gravel <1%.
		EXB03-248	15/11				Light olive gray; firm; 20% medium sand. 249.0'
250	73.6					sp/gm	GRAVELLY SAND WITH SILT; very wet; very soft; 10% fine sand; 20% medium sand; 30% coarse sand; 35% very coarse sand; silt <1%.
							Silt increase to 30%. 253.0'
		EXB03-254				sw	SANDY, GRAVELLY SILT; moderate orange pink; moist; very hard; sandy with gravel clasts at top. Grades to medium sand 20% at base.
255	68.6						TOTAL DEPTH 255 FEET
260	63.6						
265	58.6						
270	53.6						
275	48.6						
280	43.6						

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Rotasonic
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: Site 5
PROJECT NO.: 409724

EXB03(FA002)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-04

FIELD GEOLOGIST J. Strack
CHECKED BY T. Ault
APPROVED BY T. Ault
TOTAL DEPTH 250 ft.

COORDINATES: N. 2,162,573
E. 6,352,491
DATE BEGAN 10-26-93
DATE FINISHED 10-28-93
GROUND SURFACE ELEV. 321.1 ft

DEPTH IN FEET	ELEVATION IN FEET
0	321.1
5	316.1
10	311.1
15	306.1
20	301.1
25	296.1
30	291.1
35	286.1
40	281.1
45	276.1
50	271.1
55	266.1
60	261.1
65	256.1
70	251.1

SAMPLE TYPE & NUMBER: DB04-45 (at 45 ft)

RECOVERY/DRIVE (ft.), in order from top: 4/4, 3/3, 4/3, 4/3, 5/3, 4/4, 6/8, (blank), 8/7, 7/8, 21/18, 19/16

DRILLING REMARKS: —

P.I.D. READING (ppm): —

USCS	PROFILE	DESCRIPTION	Depth
fill		Asphalt; sand/gravel subgrade.	0.5'
sm		SILTY SAND; moderate brown to dusky brown; slightly moist to moist; medium dense; subangular; very fine to fine; 80% sand; 20% silt. Silt content increases 7–8 ft.	8.0'
ml		SANDY SILT; light brown to moderate yellowish brown; slightly moist; stiff to very stiff; nonplastic; becoming pale yellowish brown; soft to stiff at 10 ft.; 65% silt; 35% very fine sand; micaceous; sand content decreased to 20% from 10 to 11 ft.	12.0'
sm		SILTY SAND; light olive gray; slightly moist; loose to medium dense; very fine to fine; 75% sand; 25% silt. Becoming moderate brown at 16 ft. Sand increasing to 85%; very fine to medium; more micaceous 16 to 17.5 ft.	17.5'
ml		SANDY SILT; moderate brown; slightly moist; stiff; nonplastic; 85% silt; 45% very fine sand; fine mica abundant. Trace medium to coarse sand grains appearing in matrix.	29.0'
sm		SILTY SAND; moderate brown; slightly moist; medium dense; subangular to angular; very fine to coarse; 80% sand; 20% silt; predominantly fine fine grain.	35.5'
ml		SANDY SILT; moderate brown; slightly moist; stiff nonplastic; 65% silt; 35% very fine to fine sand.	
		SILT WITH SAND; moderate brown; slightly moist; stiff; nonplastic; 80% s[illegible] 20% very fine sand.	
		SANDY SILT; moderate brown; slightly moist; very stiff; nonplastic; 65% silt; 35% very fine to fine sand; micaceous.	45.0'
sm		SILTY SAND; moderate brown; slightly moist; medium dense; subangular; very fine to coarse; micaceous; 75% sand; 25% silt; mottled with dark reddish brown oxidation near 46 ft. Silt content increasing near 54 ft.	55.0'
ml		SILT WITH SAND; dark yellowish brown; slightly moist; very stiff to hard; nonplastic; 80% silt; 20% very fine sand.	
		SILT; pale yellowish brown; moist; stiff; low to nonplastic; trace very fine sand. Trace oxidation and reddish mottling 68 to 70 ft.	

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: South perimeter, McKinley Ave.
PROJECT NO.: 409724

SEE LEGEND FOR LOGS AN[D] TEST PITS FOR EXPLANATIO[N] OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

EXB04(FA002)

SOIL BORING EXB-04

FIELD GEOLOGIST J. Strack
CHECKED BY T. Ault
APPROVED BY T. Ault
TOTAL DEPTH 250 ft.
COORDINATES: N. 2,162,573 E. 6,352,491
DATE BEGAN 10-26-93
DATE FINISHED 10-28-93
GROUND SURFACE ELEV. 321.1 ft.

DEPTH IN FEET	ELEVATION IN FEET
70	251.1
75	246.1
80	241.1
85	236.1
90	231.1
95	226.1
100	221.1
105	216.1
110	211.1
115	206.1
120	201.1
125	196.1
130	191.1
135	186.1
140	181.1

SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)
	10/11
EXB04-95	21/19
EXB04-106	
EXB04-116	30/26
EXB04-138	13/10

DRILLING REMARKS: 243.2' el.

P.I.D. READING (ppm):

USCS	DESCRIPTION
ml	SILT; (see sheet 1 of 4)
sm	Silty Sand transition 70.5 to 71 ft. (very fine)
sp	SAND; dark yellowish orange; slightly moist; loose to medium dense; very fine to fine; trace silt. 75.0'
sm	SILTY SAND; moderate yellowish brown; moist; medium dense; very fine; 45% silt; 55% sand. 78.0'
sp	SAND; pale yellowish brown; moist; loose; very fine to fine. 81.0'
ml	SILT WITH SAND; yellowish gray to light olive gray; very moist; soft to stiff; non plastic; 80% silt; 20% very fine sand. 86.0'
ml	SILT; light olive gray to moderate olive brown; moist; stiff to very stiff; very low plasticity; trace clay and very fine sand. Becomes soft; nonplastic; 92 to 93 ft.; devoid of clay below 92 ft. A few root tubes; oxidation near 95 ft. Micro-lense of silty sand 2-3 inches thick near 101 ft. 101.0'
ml	SILT WITH SAND; lightly olive gray; moist; very stiff to hard; nonplastic; 85% silt; 15% very fine sand; sand content increases; becomes very fine to medium fine near 103.5 ft. 103.0'
sm	SILTY SAND; moderate olive brown; very moist; dense; very fine to medium; 70% sand; 30% silt. 105.0'
ml	SANDY SILT; dark yellowish brown; wet; stiff; nonplastic; micaceous; 60% silt; 40% very fine sand. 107.5'
ml	SILT WITH SAND; moderate brown; wet; very stiff to hard; nonplastic; cemented matrix; 75% silt; 25% very fine to fine sand. Sand decreases to 15%; very fine; becomes moderate yellowish brown to 116 ft. Becomes mottled; light brown and grayish orange 116 to 118 ft.; sand content increases. 118.0'
ml	SANDY SILT; dark yellowish brown to moderate brown; very moist; very stiff; very low plasticity; 65% silt; 35% very fine to fine sand; trace medium sand and clay; sand content increasing sand 119 to 120 ft. Sand content decreasing 120 to 121 ft. 121.0'
ml	SILT; moderate brown; slightly moist; very stiff to hard; nonplastic; trace sand and minor evidence of orgasmic matter. 128.0'
ml	SILT WITH SAND; moderate brown; slightly moist; very stiff; nonplastic; 80% silt; 20% very fine to fine sand. 130.0'
ml	SANDY SILT; moderate brown; very moist; very stiff; nonplastic; 65% silt; 35% very fine to fine sand. Sand content increases to near 50% 132.5 to 133.0 ft. 133.0'
ml	SILT; pale yellowish brown; moist; stiff; nonplastic; trace; sand and moderate brown mottling. 135.6'
sm	SILTY SAND; moderate yellowish brown; wet; dense; very fine to fine; micaceous; 65% sand; 35% silt; sand coarsening; increasing downward. 138.0'
sw	SAND; grayish orange to dark yellowish orange; wet; loose; to medium dense; very fine to coarse; 95% sand; 5% silt; sand fine from 139.5 to 140.0 ft.; silt increasing. 140.0'

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: South perimeter, McKinley Ave.
PROJECT NO.: 409724

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

EXB04(FA002)

SOIL BORING EXB-04

FIELD GEOLOGIST: J. Strack
CHECKED BY: T. Ault
APPROVED BY: T. Ault
TOTAL DEPTH: 250 ft.
COORDINATES: N. 2,162,573 E. 6,352,491
DATE BEGAN: 10-26-93
DATE FINISHED: 10-28-93
GROUND SURFACE ELEV. 321.1 ft.

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)	DRILLING REMARKS	P.I.D. READING (ppm)	USCS	DESCRIPTION
140–147.0	181.1	EXB-04 142	25/20			sw	SAND; moderate yellowish brown; wet; medium dense; subangular/ subrounded; very fine to coarse; trace silt; micaceous. 147.0'
147.0–148.0						sm	SILTY SAND; predominantly very fine to medium grained; 80% sand; 20% silt. 148.0'
148.0–151.0		EXB-04 150				sw	SAND WITH GRAVEL; dark yellowish brown; wet; medium dense subrounded to rounded; very fine to very coarse; predominantly coarse grained; 95% sand; 5% very fine gravel to 3mm; trace silt; micaceous. 151.0'
151.0–155.0		EXB-04 151				ml	SILT WITH SAND; moderate brown; wet; soft to stiff; nonplastic; slightly micaceous; 85% silt; 15% very fine sand. 155.0'
155.0–157.0						ml	SANDY SILT; moderate brown; wet; stiff to very stiff; nonplastic; 60% silt; 40% very fine to fine sand. 157.0'
157.0–158.0						sm	SILTY SAND; lense 157–158 ft. 158.0'
158.0–164.0	161.1	EXB-04 162	23/20			ml	SANDY SILT; as from 155 ft. Sand content increases to 40 to 45%. Becomes fine to medium. 164.0'
164.0–170.0						sm	SILTY SAND; medium olive brown to olive gray; wet; medium dense; subrounded very fine to very coarse; 60% sand; 40% silt. 170.0'
170.0–170.5						ml	SILT WITH SAND; moderate brown; moist; very stiff. 170.5'
170.5–176.0						sw	SAND WITH SILT; dark yellowish brown; wet; medium dense; very fine to medium; 90% sand; 10% silt; micaceous. Becoming medium to very coarse with trace silt; 175 to 176 ft. 176.0'
176.0–180.0		EXB-04 180				ml	SANDY SILT; moderate brown; very moist; very stiff; nonplastic; 60% silt; 40% very fine to fine sand. Sand content decreases to 30% at 179 ft. 180.0'
180.0–182.0	141.1		4/4			ml	SANDY SILT; moderate brown; wet; very stiff to hard with some cementation; 55% silt; 45% very fine to medium sand. 182.0'
182.0–186.0		EXB-04 185	17/16			sm	SILTY SAND; moderate brown; wet; dense; very fine to medium; 60% sand; 40% silt; trace coarse sand and mica. 186.0'
186.0–189.0		EXB-04 188				ml	SANDY SILT; moderate brown to moderate yellowish brown; very moist; very stiff to hard; nonplastic; 55% silt; 45% very fine to medium sand. 189.0'
189.0–190.0						sm	SILTY SAND; moderate yellowish brown; slightly moist to wet; dense; very fine medium; 60% sand; 40% silt. 190.0'
190.0–192.0						ml	SILT WITH SAND; moderate brown; hard; nonplastic; 80% silt; 20% sand. 192.0'
192.0–195.0						sm	SILTY SAND; moderate brown; very moist; dense; very fine to very coarse; 85% sand; 15% silt; trace very fine gravel 194 to 195 ft. 195.0'
195.0–199.0						ml	SILT; light brown; slightly moist; hard; very low plasticity; trace sand and clay. 199.0'
199.0–204.0	121.1		0/4			ml	SILT WITH SAND; moderate brown to medium reddish brown; slightly moist; hard; nonplastic; 85% silt; 15% sand; very fine to medium; trace mica. Becoming slightly plastic; trace clay. 204.0'
204.0–207.0	116.1	EXB-04 206, EXB-04 207				sm	SILTY SAND; moderate brown; wet; medium dense; very fine to medium; 75% sand; 25% silt. Becoming very fine to coarse with 15% silt 206 to 209 ft. 207.0'
207.0–210	111.1	EXB-04 208				ml	SILT; moderate yellowish brown to dark yellowish orange; slightly moist; hard; nonplastic; 90% silt; 10% sand.

Depth/elevation scale: 140 – 181.1; 145 – 176.1; 150 – 171.1; 155 – 166.1; 160 – 161.1; 165 – 156.1; 170 – 151.1; 175 – 146.1; 180 – 141.1; 185 – 136.1; 190 – 131.1; 195 – 126.1; 200 – 121.1; 205 – 116.1; 210 – 111.1

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: South perimeter, McKinley Ave.
PROJECT NO.: 409724

EXB04(FA002)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-04

FIELD GEOLOGIST J. Strock	COORDINATES: N. 2,162,573 E. 6,352,491
CHECKED BY T. Ault	DATE BEGAN 10-26-93
APPROVED BY T. Ault	DATE FINISHED 10-28-93
TOTAL DEPTH 250 ft.	GROUND SURFACE ELEV. 321.1 ft.

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)	DRILLING REMARKS	P.I.D. READING (ppm)	USCS	DESCRIPTION
210	111.1						
215	106.1		20/16				Sand content increases 216 to 217 ft. 217.0'
220	101.1					ml	SANDY SILT; moderate brown; very moist; stiff; very low to nonplastic; 60% silt; 40% very fine sand; micaceous; trace clay; Becomes devoid of clay; nonplastic; sand content decreases 220 to 221 ft. 221.0'
225	96.1						SILT WITH SAND; light brown; slightly moist; very stiff to hard; nonplastic; 85% silt; 15% very fine sand. 228.0'
			21/16			sm	SILTY SAND; lense 228–228.5 ft.; wet; dense; very fine to coarse. 228.5'
230	91.1					ml	SILT; moderate brown to variegated; slightly moist; hard to very hard; nonplastic; 90% silt; 10% sand; trace very fine subangular gravel. Microlense of dry, cemented silty sand near 233 ft.; grayish orange pink to very pale orange with silt laminations and trace angular quartz. 234.0'
235	86.1						SILT; mottled dark yellowish brown to olive gray; slightly moist to moist; stiff; nonplastic; 90% silt; 10% sand trace very fine gravel; sand content increased to 15% very fine to coarse angular 136–137 ft. 237.0'
240	81.1					sm	SILTY SAND WITH GRAVEL; dark yellowish orange to moderate yellowish brown; slightly moist; very dense; subangular to angular; fine to very coarse; 75% silt; 15% silt; 10% angular gravel; some large mica flares up to 4mm.; (predominantly quartz). 241.0'
		EXB-04 241	17/14			ml	SILT; moderate brown to moderate yellowish brown; dry to slightly moist; hard to very hard; nonplastic; 90% silt; 10% very fine sand; trace very fine mica and clay.
245	76.1						
250	71.1						TOTAL DEPTH 250 FEET
255	66.1						
260	61.1						
265	56.1						
270	51.1						
275	46.1						
280	41.1						

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: South perimeter, McKinley Ave.
PROJECT NO.: 409724

EXB04(FA002)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-05

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 259 ft.

COORDINATES: N. 2,162,522
E. 6,351,777
DATE BEGAN 10-18-93
DATE FINISHED 10-21-93
GROUND SURFACE ELEV. 320.3

DEPTH IN FEET	ELEVATION IN FEET
0	320.3
5	315.3
10	310.3
15	305.3
20	300.3
25	295.3
30	290.3
35	285.3
40	280.3
45	275.3
50	270.3
55	265.3
60	260.3
65	255.3
70	250.3

SAMPLE TYPE & NUMBER: EXB05-15

RECOVERY/DRIVE (ft.): 0.5/6; NR; 13/8; 4/5; 10/10; 36/20

DRILLING REMARKS

P.I.D. READING (ppm)

USCS	PROFILE	DESCRIPTION	
		Asphalt	0.5'
sp		SAND; dark yellowish brown; very moist; very soft; medium sand.	7.0'
sm		SILTY SAND; light brown; slighlty moist; soft; medium sand; silt 10%; increased silt with depth; silt 40%.	9.0'
cl		CLAY; light olive green; slightly firm; moist; low plastic.	10.0'
sp		SAND; light brown; very moist; soft; coarse sand; silt <1%	12.0'
sm		SILTY SAND; moderate brown; hard; platy; medium to coarse sand; silt 10-20%	14.0'
ml		SILT; light brown; slightly moist; hard; nonplastic. Sandy to 5%	17.5'
sm		SILTY SAND; medium yellow brown; firm; moist; platy sand; medium to coarse; 30% silt.	19.5'
cl		CLAY/SANDY CLAY; light olive gray; very moist; soft; low plastic; increase sand with depth to 5%	21.5'
ml		SANDY SILT; moderate brown; firm; very moist.	23.0'
sp		SAND; light brown; very soft; very moist, medium coarse to very coarse sand (poorly graded). Very wet.	31.0'
ml		SILT with SAND; light brown; firm; very moist; medium to coarse sand 20% medium sand 20% Fine sand 10%	37.0'
sm		SAND with SILT; medium coarse sand; light brown; slightly moist;	39.0'
cl		CLAY; light olive gray; very moist; medium to low plastic; medium sand <1%	40.0'
sp		SAND; dark yellow orange; very moist; very soft; very fine sand. Coarse with depth; very coarse with 6" to fine gravel.	44.0'
cl		SILTY CLAY; light olive gray; silty at top; very slightly plastic. Clay predominant below 44 ft. Medium to low plastic.	47.0'
ml		SILT; light brown; firm; slightly moist; nonplastic.	51.0'
cl		SILTY CLAY/CLAYEY SILT; light olive gray; low to medium plastic; very wet.	55.0'
ml		SILT; light brown; firm; slightly moist; nonplastic.	60.0'
		SANDY SILT; moderate brown; slightly moist; stiff; nonplastic; 60% silt; 40% very fine sand; sand content increased to 50-60% near 64 to 65 ft.	65.0'
		SILT WITH SAND; dark yellowish brown; slightly moist; very stiff to hard; very low plasticity; 75% silt; 25% very fine sand; trace clay.	

See next sheet

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: South perimeter, McKinley Ave.
PROJECT NO.: 409724

EXB05(FA002)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-05

FIELD GEOLOGIST T. Ault — COORDINATES: N. 2,162,522 E. 6,351,777
CHECKED BY T. Ault — DATE BEGAN 10-18-93
APPROVED BY S. Logan — DATE FINISHED 10-21-93
TOTAL DEPTH 259 ft. — GROUND SURFACE ELEV. 320.3

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)	DRILLING REMARKS	P.I.D. READING (ppm)	USCS	DESCRIPTION
70	250.3		25/20			ml	SANDY SILT; moderate yellowish brown; slightly moist; stiff; very low to nonplastic; 70% silt; 30% very fine sand; trace very fine micas. Sand content increasing. 74.0'
75	245.3					sm	SILTY SAND; pale brown to pale yellowish brown; slightly moist to dry; medium dense; very fine sand; 65% sand; 35% silt; silt increases 76 to 77 ft. 77.0'
				▼ 241.5' el.		sp	SAND; moderate yellowish brown; dry; loose; subangular; very fine to fine sand; trace silt. 79.0'
80	240.3		11/8			sm	SILTY SAND; dark yellowish brown; moist; medium dense; very fine; 80% sand; 20% silt. 80.0'
						ml	SANDY SILT; moderate brown; moist; stiff; nonplastic; 60% silt; 40% very fine sand. 81.5'
							SILT; light olive gray; slightly moist; very stiff; nonplastic; abundant zones of oxidation; sand appearing near 85 ft. 84.5'
85	235.3					sm	SILTY SAND; dark yellowish brown; very moist to wet; medium dense; subrounded to subangular; very fine to coarse; 85% sand; 15% silt; silt content increases 88 to 88.5 ft. 88.5'
		EXB05-89.5				cl	SILTY CLAY; light olive gray to moderate olive brown; slightly moist; hard; low to medium plasticity. 90.0'
90	230.3		24/20			ml	SILT WITH CLAY; olive gray; moist; stiff to very stiff; very low to nonplastic; becoming very stiff to hard and clay decreased to trace near 95 ft. 96.0'
95	225.3					ml	SILT WITH SAND; light olive gray to grayish olive; moist; stiff; nonplastic; 80% silt; 20% very fine sand; sand content increasing near 103 ft. 103.0'
100	220.3						
						sm	SILTY SAND; light olive gray; wet; medium dense; subangular; very fine to coarse; 75% sand; 25% silt; sand content decreases 105 to 106 ft. 106.0'
105	215.3		25/15			ml	SANDY SILT; moderate brown; wet; stiff; nonplastic; 65% silt; 35% very fine to fine sand. 109.0'
		EXB01-108				ml	SILT WITH SAND; moderate brown; wet; very stiff to hard; nonplastic; 80% silt; 20% very fine sand. Mottled light brown and trace fine to medium sand grains near 120 ft. 121.0'
110	210.3						
115	205.3						
120	200.3		25/20			ml	SANDY SILT; moderate yellowish brown to dark brown; very moist; very stiff; nonplastic; 70% silt; 30% very fine to fine sand; trace coarse to very coarse rounded sand. 124.0'
125	195.3					sm	SILTY SAND; moderate yellowish brown; wet; medium dense; cohesive matrix; very fine to medium; subrounded; 60% sand; 40% silt. 127.0'
130	190.3					ml	SILT; dark yellowish brown; mottled with moderate brown and light olive gray; soft to stiff; very moist to wet; nonplastic; trace very fine sand throughout with micaceous lense and 15-20% very fine sand near 130 ft. 137.0'
135	185.3						
						sm	SILTY SAND LENSE; 60% very fine to fine sand; 40% silt; trace mica. 138.0'
140	180.3					ml	SILT; (as from 127 ft.) mottled; reddish brown oxidation.

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: South perimeter, McKinley Ave.
PROJECT NO.: 409724

EXB05(FA002)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-05

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 259 ft.
COORDINATES: N. 2,162,522 E. 6,351,777
DATE BEGAN 10-18-93
DATE FINISHED 10-21-93
GROUND SURFACE ELEV. 320.3

DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)	DRILLING REMARKS	P.I.D. READING (ppm)	USCS	PROFILE	DESCRIPTION
140	180.3					ml		(See previous sheet) 142.0'
		EXB05-143				sm		SILTY SAND; moderate olive brown to dark yellowish brown; wet; medium dense; very fine to medium; micaceous; 85% sand; 15% silt. 148.0'
145	175.3							
		EXB05-148	20/20			ml		SANDY SILT; dark yellowish brown; moist; very stiff; nonplastic; 65% silt; 35% very fine to fine sand; trace mica. Silty sand interbed less than 1 ft. thick 152-153 ft. (very fine to fine) Becoming very stiff to hard 153 to 157 ft. Sand content increasing 157 to 159 ft. 159.0'
150	170.3							
155	165.3							
160	160.3					sm		SILTY SAND; moderate yellowish brown; wet; dense; subrounded; very fine to very coarse with trace very fine gravel near 159.5 ft.; 80% sand; 20% silt. 161.0'
		EXB05-162	14/10			sw		SAND WITH SILT; same as from 159 ft.; with 90% sand; 10% silt. 163.0'
165	155.3	EXB05-167				ml		SILT WITH SAND; moderate brown; slightly moist to moist; very stiff; very low plasticity; 80% silt; 20% very fine sand. Becoming hard; 160 to 167 ft. Sand content increasing 167 to 168 ft. 168.0'
						sm		SILTY SAND; olive gray to moderate olive brown; wet; dense; rounded/sub-rounded; very fine very coarse; trace very fine gravel; 85% sand; 15% silt. 170.0'
170	150.3	EXB05-171				sw		MEDIUM DENSE WELL GRADED LENS WITH TRACE SILT 171.0'
						sm		See 168 ft. description 172.0'
			23/20			ml		SILT WITH SAND; dark yellowish brown; stiff to very stiff; moist; very low plasticity; 75% silt; 25% very fine sand. Becoming very stiff to hard; nonplastic; 179 to 180 ft. Sand content increasing; becoming stiff; nonplastic 184 to 185 ft. 185.0'
175	145.3							
180	140.3							
185	135.3							SANDY SILT; dark yellowish brown; very moist; stiff; nonplastic; 65% silt; 35% very fine to fine sand. 187.0'
		EXB05-188						SILT WITH CLAY; moderate reddish brown to light brown; hard to very hard; slightly moist; low plasticity; trace to 5% sand. 190.0'
190	130.3		12/6			ml		SILT WITH SAND; moderate yellowish brown; slightly moist; hard to very hard; nonplastic; 75% silt; 25% very fine to medium sand. Becoming slightly micaceous with some black mottling; possibly root tubes 194 to 195 ft. 197.0'
195	125.3		4/5					
								SANDY SILT; dark yellowish brown to moderate olive brown; very moist; stiff; nonplastic; 60% silt; 40% very fine to medium sand; microlense of silty sand; (well graded, fining up); 3-4" thick near 198 ft. Silt content increasing becoming very stiff 200 to 201 ft. 201.0'
200	120.3	EXB05-202						SILT; pale yellowish brown; slightly firm; very moist; very slightly plastic. 204.0'
205	115.3							SILT WITH SAND; moderate brown; moist; hard; <5% medium sand. Coarse sand <5%; platy fracture; soft. 208.0'
								SILT; light brown; soft; very moist; nonplastic. 209.0'
210	110.3							See next sheet

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: South perimeter, McKinley Ave.
PROJECT NO.: 409724

EXB05(FA002)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION

SOIL BORING EXB-05

FIELD GEOLOGIST T. Ault
CHECKED BY T. Ault
APPROVED BY S. Logan
TOTAL DEPTH 259 ft.

COORDINATES: N. 2,162,522
E. 6,351,777
DATE BEGAN 10-18-93
DATE FINISHED 10-21-93
GROUND SURFACE ELEV. 320.3

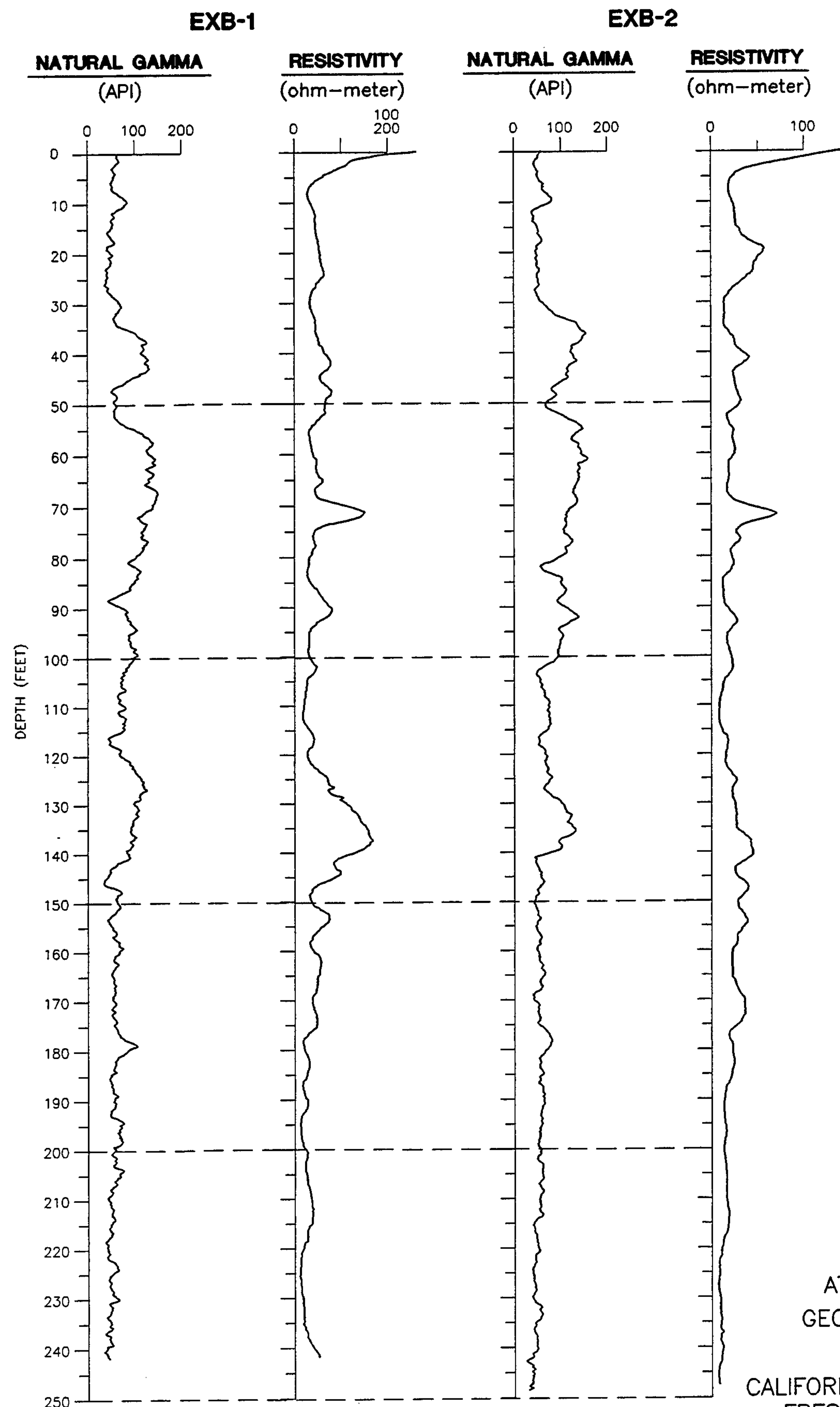
DEPTH IN FEET	ELEVATION IN FEET	SAMPLE TYPE & NUMBER	RECOVERY/DRIVE (ft.)	DRILLING REMARKS	P.I.D. READING (ppm)	USCS	DESCRIPTION
210	110.3					ml	SILTY WITH SAND; moderate yellow brown; slightly moist; very hard; medium to very coarse sand <1%.
215	105.3		3/20				
						s?	-?- -?- -?- -?- -?- -?- -?- -?- -?- -?- SAND; no sample return for description. -?- -?- -?- -?- -?- -?- -?- -?- -?- -?-
220	100.3	EXB05-223				ml	SILT; grayish orange; dry; very hard; medium or coarse sand <10%; nonplastic.
225	95.3		16/16				
230	90.3						
235	85.3						239.0'
240	80.3		19/11				SANDY SILT; light olive gray; firm; moist; medium sand; fine sand 30%; very slightly plastic. 242.0'
							SILT; pale yellow brown; firm; moist; very slightly plastic. Clayey at base. 246.0'
245	75.3	EXB05-244					SANDY SILT; medium yellow brown; very soft; very wet; nonplastic; firm at 247 ft. 248.0'
250	70.3	EXB05-251	8/12			sp	SAND; dark yellow orange and olive gray; very soft; wet; medium sand; trace silt <1%. Silt increases at base. 256.0'
255	65.3					ml	CLAYEY SILT; pale brown; hard; dry; slightly plastic. 258.0'
						sp	SAND; light to moderate brown; firm; wet; coarse grain.
260	60.3						TOTAL DEPTH 259 FEET
265	55.3						
270	50.3						
275	45.3						
280	40.3						

DRILLING CO.: Water Development Corp.
DRILLER: Mike Wilkenson
DRILLING METHOD: Sonicore
SAMPLING METHOD: Core
CLIENT: HAZWRAP
LOCATION: South perimeter, McKinley Ave.
PROJECT NO.: 409724

EXB05(FA002)

SEE LEGEND FOR LOGS AND TEST PITS FOR EXPLANATION OF SYMBOLS AND TERMS

INTERNATIONAL TECHNOLOGY CORPORATION



409724-A1
DRAWING NUMBER
CHECKED BY
APPROVED BY
SJZ
10-17-94
DRAWN BY

ATTACHMENT #1
GEOPHYSICAL LOGS
PREPARED FOR
CALIFORNIA NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNNIA

INTERNATIONAL TECHNOLOGY CORPORATION

FA-EXBSL(FA002)

APPENDIX G

GEOTECHNICAL SAMPLE RESULTS

Table G-1

Deep Aquifer Investigation
Soil Geotechnical Sample Results
California Air National Guard - Fresno, California

(Page 1 of 2)

Sample ID	Moisture Content (%)	Bulk Density		Dry Density		Specific Gravity	Effective Porosity	Vertical Hydraulic Conductivity (cm/s)	Total Organic Carbon	
		lb/ft^3	g/cm^3	lb/ft^3	g/cm^3				mg/kg	%
Fine Grained Samples										
EXB-02-85G	30.7	119.79	1.92	91.64	1.47	2.6073	0.437	2.5×10^{-7}	190	0.019
EXB-05-89G	27.1	122.27	1.96	96.24	1.54	2.6452	0.417	1.0×10^{-8}	73	0.007
EXB-02-125G	13.1	136.30	2.18	120.53	1.93	2.6773	0.279	1.8×10^{-8}	100	0.010
EXB-03-128G	11.6	137.32	2.20	123.02	1.97	2.6511	0.257	1.3×10^{-7}	71	0.007
EXB-05-167G	12.5	139.62	2.24	124.11	1.99	2.7222	0.270	3.8×10^{-8}	69	0.007
EXB-04-180G	14.9	130.24	2.09	113.36	1.82	2.7216	0.333	5.3×10^{-8}	53	0.005
EXB-03-198G	16.9	126.39	2.02	108.12	1.73	2.7597	0.373	4.8×10^{-7}	170	0.017
EXB-04-208G	12.2	139.84	2.24	124.60	2.00	2.6990	0.261	2.0×10^{-8}	40	0.004
EXB-03-209G	9.1	136.25	2.18	124.86	2.00	2.7241	0.266	2.8×10^{-8}	78	0.008
EXB-02-238G	13.8	136.59	2.19	120.05	1.92	2.7052	0.289	2.5×10^{-8}	33	0.003
Coarse Grained Samples										
EXB-03-97G	--	--	--	--	--	--	--	--	54	0.005
EXB-04-116G	--	--	--	--	--	--	--	--	46	0.005
EXB-04-138G	--	--	--	--	--	--	--	--	15	0.002
EXB-04-150G	--	--	--	--	--	--	--	--	ND13	NA
EXB-02-152G	--	--	--	--	--	--	--	--	140	0.014

Table G-1

Deep Aquifer Investigation
Soil Geotechnical Sample Results
California Air National Guard - Fresno, California

Sample ID	Moisture Content (%)	Bulk Density		Dry Density		Specific Gravity	Effective Porosity	Vertical Hydraulic Conductivity (cm/s)	Total Organic Carbon	
		lb/ft³	g/cm³	lb/ft³	g/cm³				mg/kg	%
EXB-03-175G	--	--	--	--	--	--	--	--	86	0.009
EXB-04-206G	--	--	--	--	--	--	--	--	46	0.005
EXB-03-248G	--	--	--	--	--	--	--	--	160	0.016

Grain-Size Analysis

Sample ID	Approximate Percentage of:						
	Gravel	Sand			Total Sand	Silt	Clay
		Coarse	Medium	Fine			
EXB-03-97G	0	0	4	38	42	55	3
EXB-04-116G	0	0	10	37	47	51	2
EXB-04-138G	0	0	17	50	67	31	2
EXB-04-150G	1	7	36	46	89	9	1
EXB-02-152G	0	1	17	53	71	27	2
EXB-03-175G	0	1	25	44	70	28	2
EXB-04-206G	1	2	29	38	69	29	1
EXB-03-248G	5	4	28	34	66	27	2

Table G-2

Site 5 RI
Soil Geotechnical Sample Results
California Air National Guard - Fresno, California

Sample ID	Bulk Density		Dry Density		Specific Gravity	Total Porosity (%)	Vertical Permeability (cm/s)	Organic Content (%)	Atterberg Limits			
	lb/ft^3	g/cm^3	lb/ft^3	g/cm^3					Liquid Limit	Plastic Limit	Plastic Index	USCS Symbol
MWBP-09-95-96.5A	116.6	1.87	83.6	1.34	2.6834	50.1	3.7×10^{-6}	0.9	32	27	5	ML
MWBP-10-90-91.5	107.9	1.73	83.4	1.34	2.6575	49.7	2.7×10^{-4}	1.6	27	24	3	ML
MWBP-11-95-96.5	114.3	1.84	85.6	1.38	2.6938	49.1	6.7×10^{-7}	1.5	30	21	9	CL
MWBP-12-91.0-91.5	118.6	1.91	92.8	1.49	2.6685	44.3	1.2×10^{-7}	1.8	Non Plastic			
SB5-01-86.0-86.5	104.0	1.67	66.7	1.07	2.6700	60.0	4.1×10^{-5}	2.1	45	26	19	CL
SB5-07-66.0-66.5	120.8	1.94	95.4	1.53	2.6765	42.9	1.1×10^{-5}	0.9	Non Plastic			

Grain-Size Analysis

Sample ID	Approximate Percentage of:						
		Sand					
	Gravel	Coarse	Medium	Fine	Total Sand	Silt	Clay
MWBP-09-95-96.5	0	2	13	9	24	74	2
MWBP-10-90-91.5	0	0	11	58	69	28	3
MWBP-11-95-96.5	0	0	4	25	29	68	3
MWBP-12-91.0-91.5	3	6	22	53	84	13	3
SB5-01-86.0-86.5	1	15	31	27	67	30	3
SB5-07-66.0-66.5	0	3	8	20	31	64	5

APPENDIX H

AQUIFER TEST ANALYSIS INFORMATION

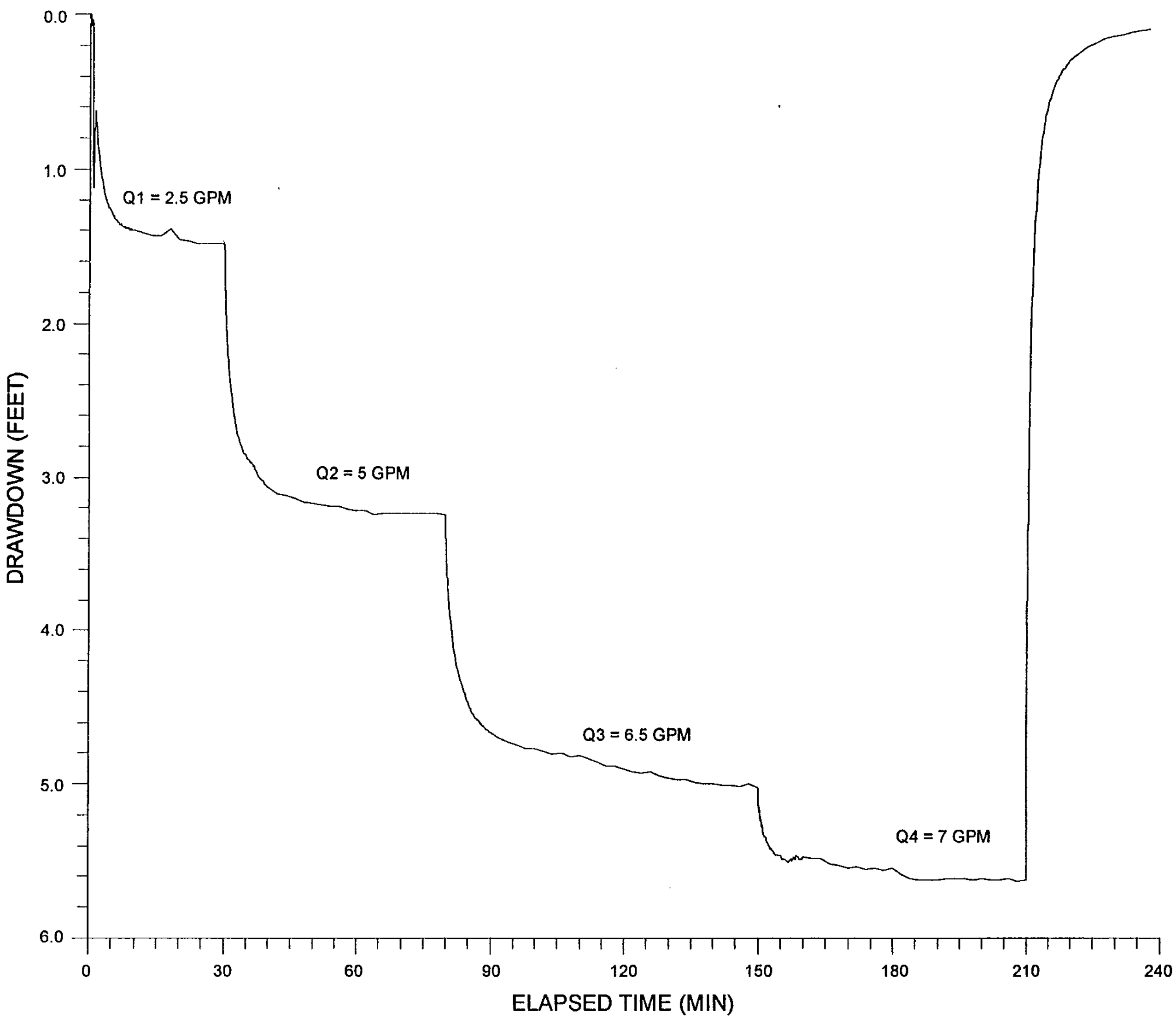


FIGURE H-1
STEP-DRAWDOWN TEST RESULTS IN MWBP-12

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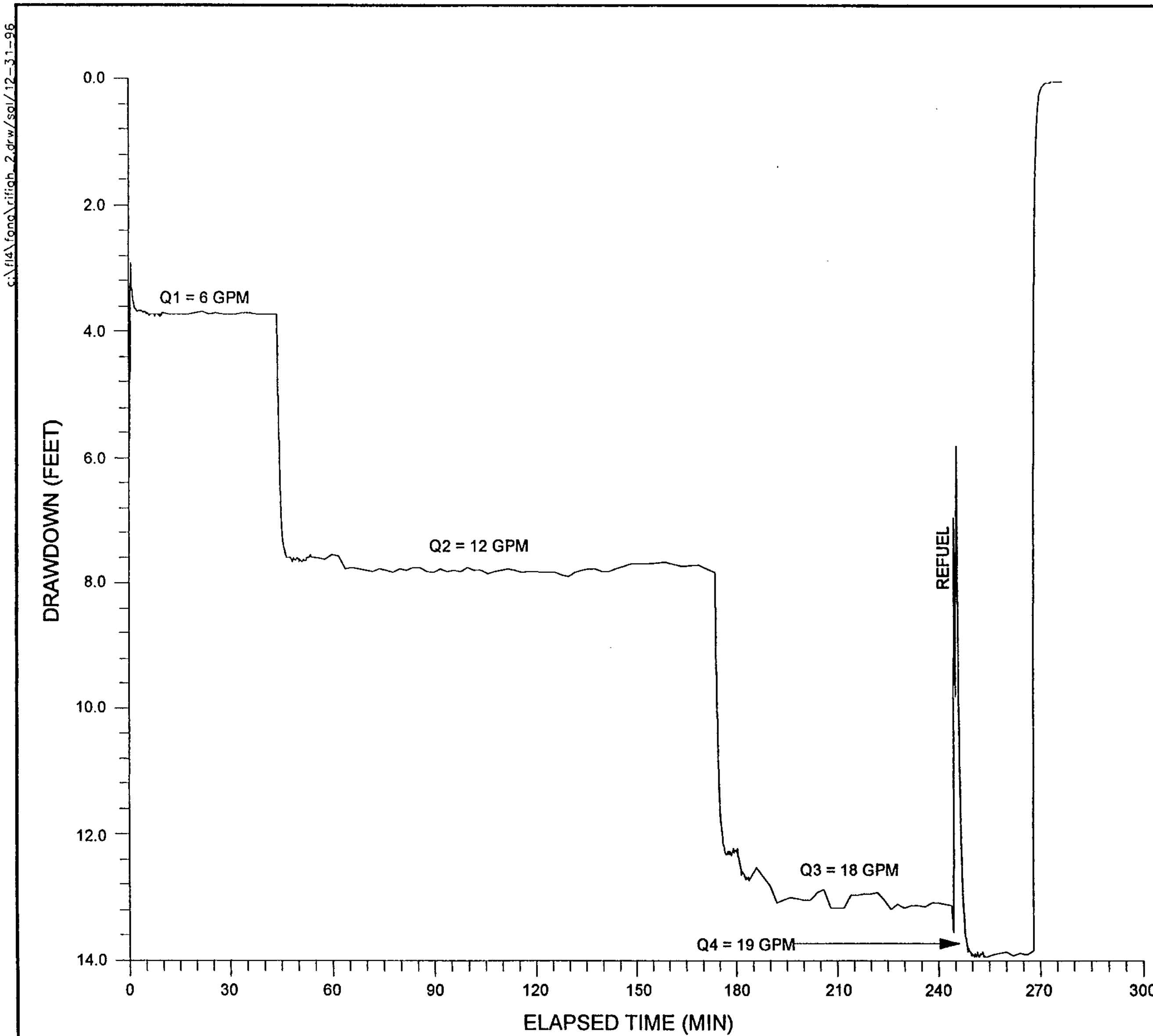

FIGURE H-2
STEP-DRAWDOWN TEST RESULTS IN MWBP-05B

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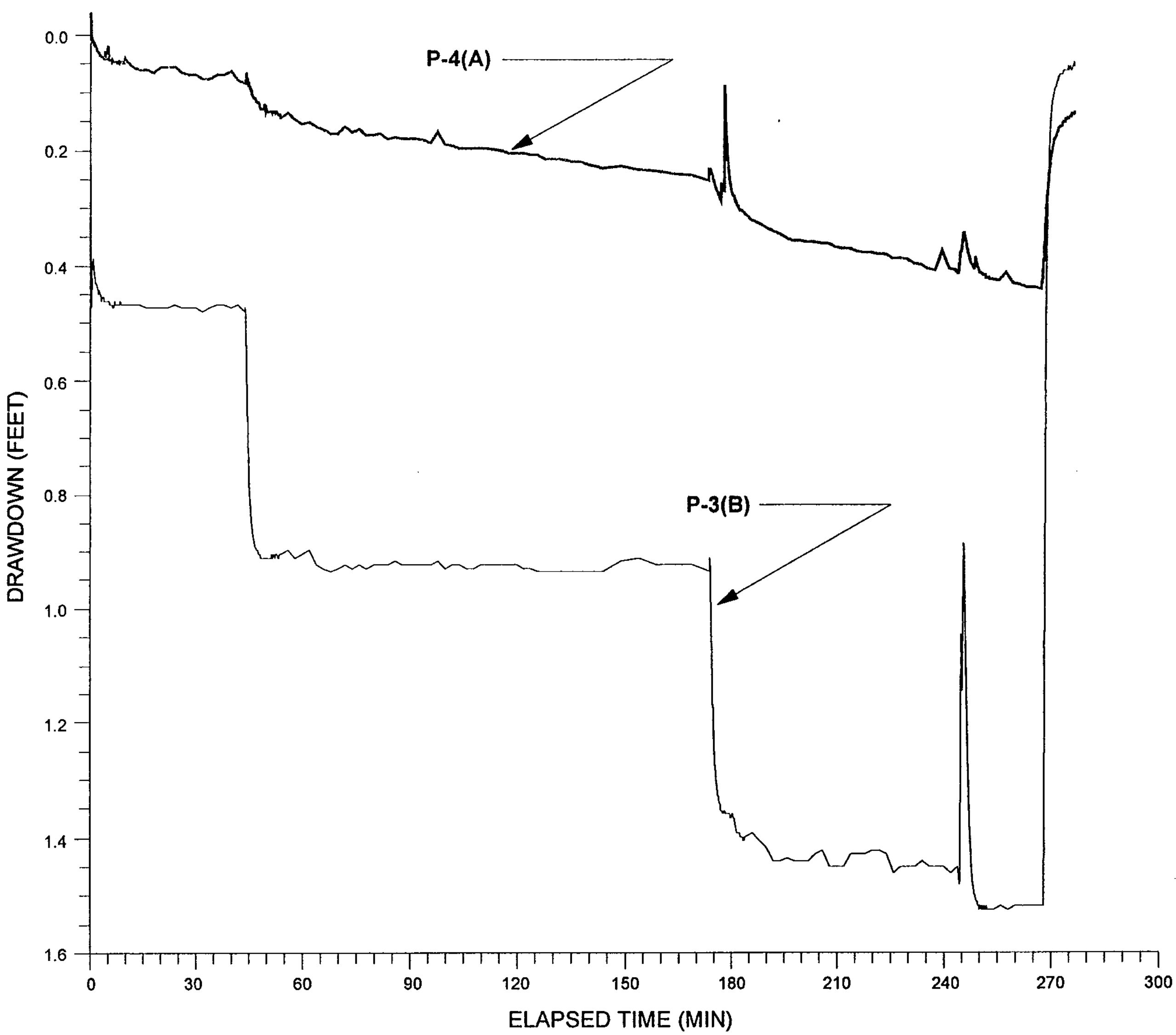

NOTES:

P-3(B) SCREENED AT SAME DEPTH INTERVAL AS MWBP-05B

P-4(A) SCREENED ACROSS THE WATER TABLE

FIGURE H-3

DRAWDOWN MEASUREMENTS IN P-3(B) AND P-4(A) DURING STEP-DRAWDOWN TEST IN MWBP-05B

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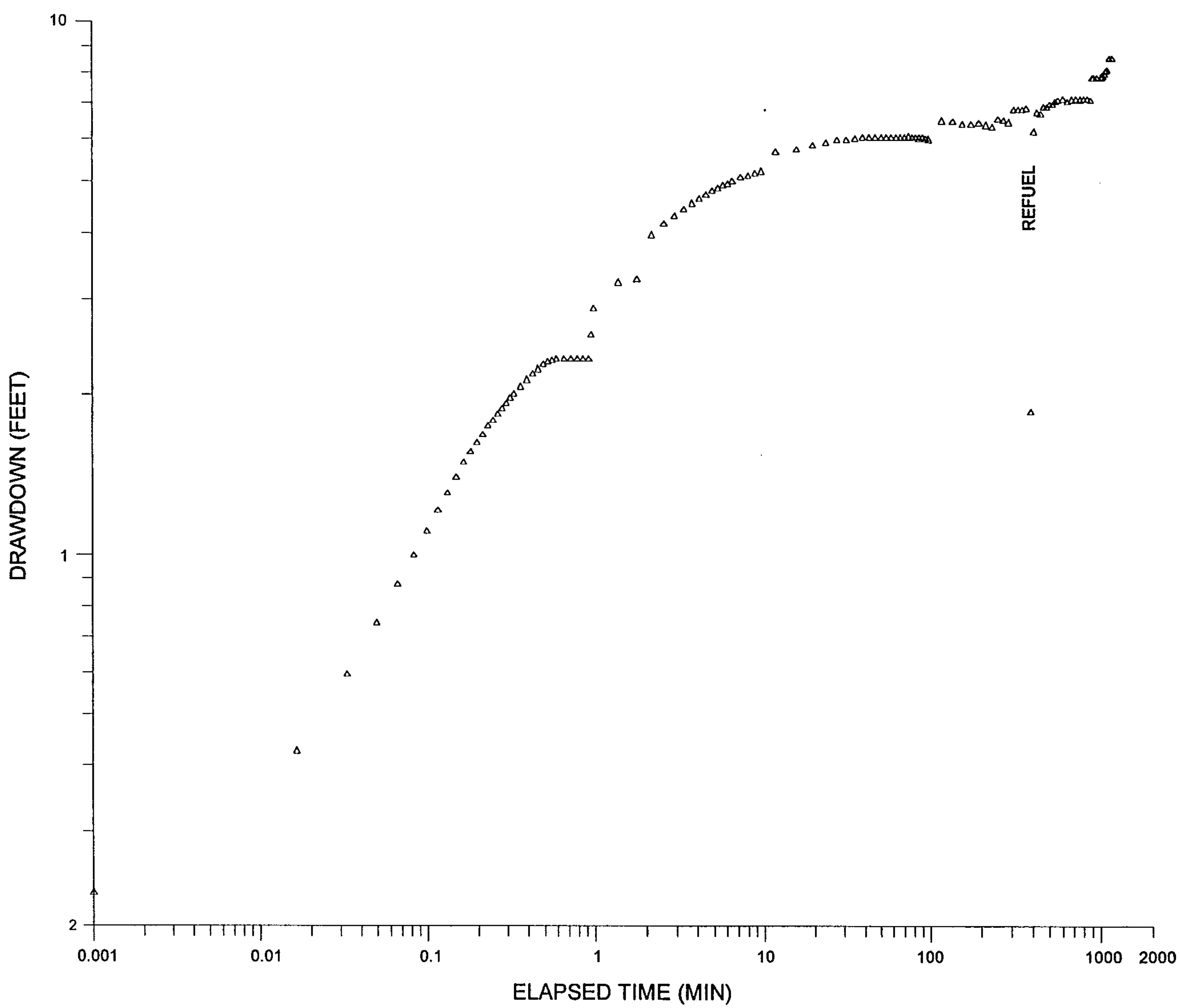

NOTES:

PUMPING RATE IN MWBP-12 IS 7.5 GPM

FIGURE H-4

CONSTANT RATE TEST RESULTS IN MWBP-12

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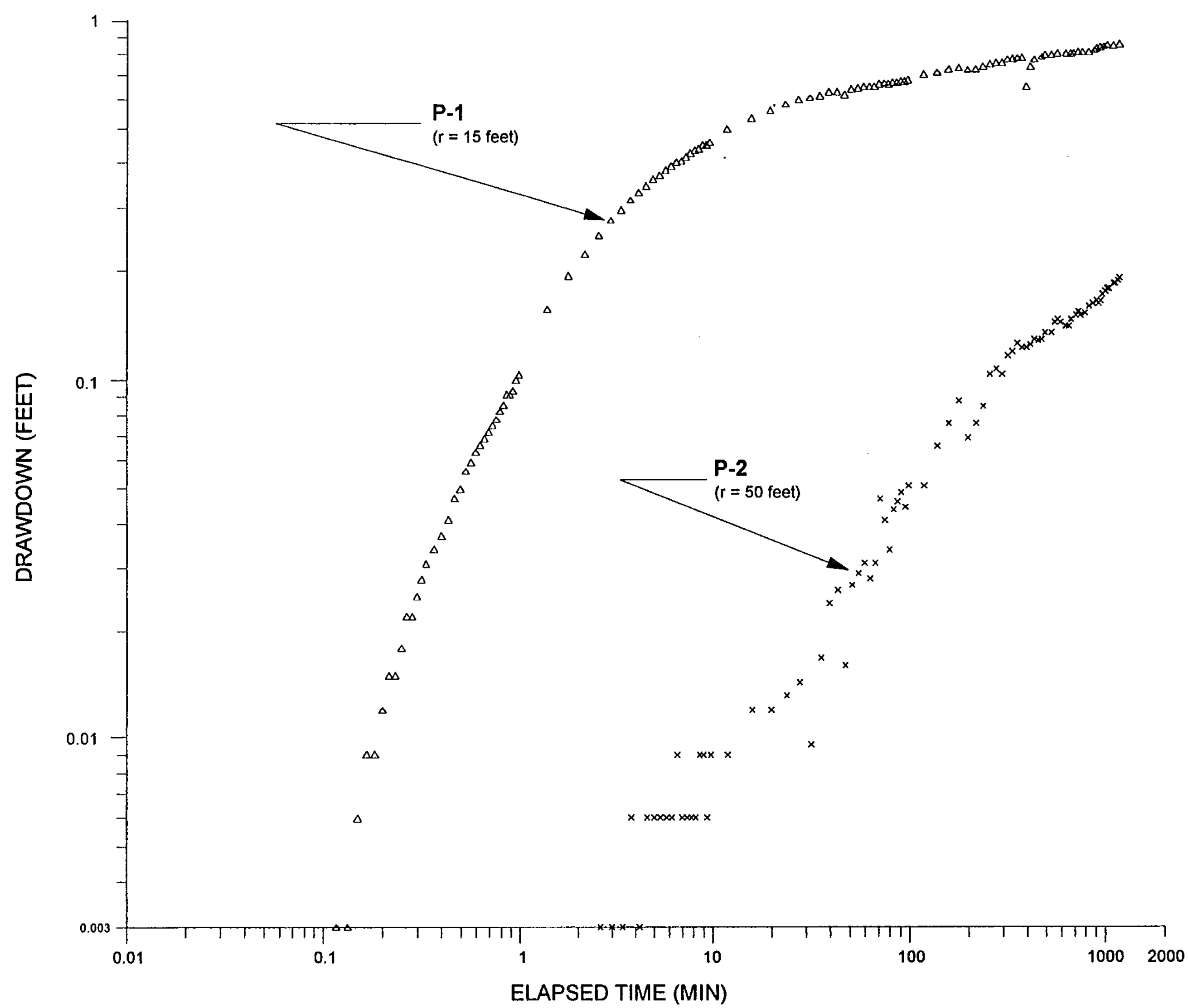

NOTES:

PUMPING RATE IN MWBP-12 IS 7.5 GPM

DRAWDOWNS HAVE BEEN CORRECTED FOR BACKGROUND FLUCTUATIONS

FIGURE H-5

DRAWDOWN MEASUREMENTS IN P-1 AND P-2 DURING CONSTANT RATE TEST IN MWBP-12

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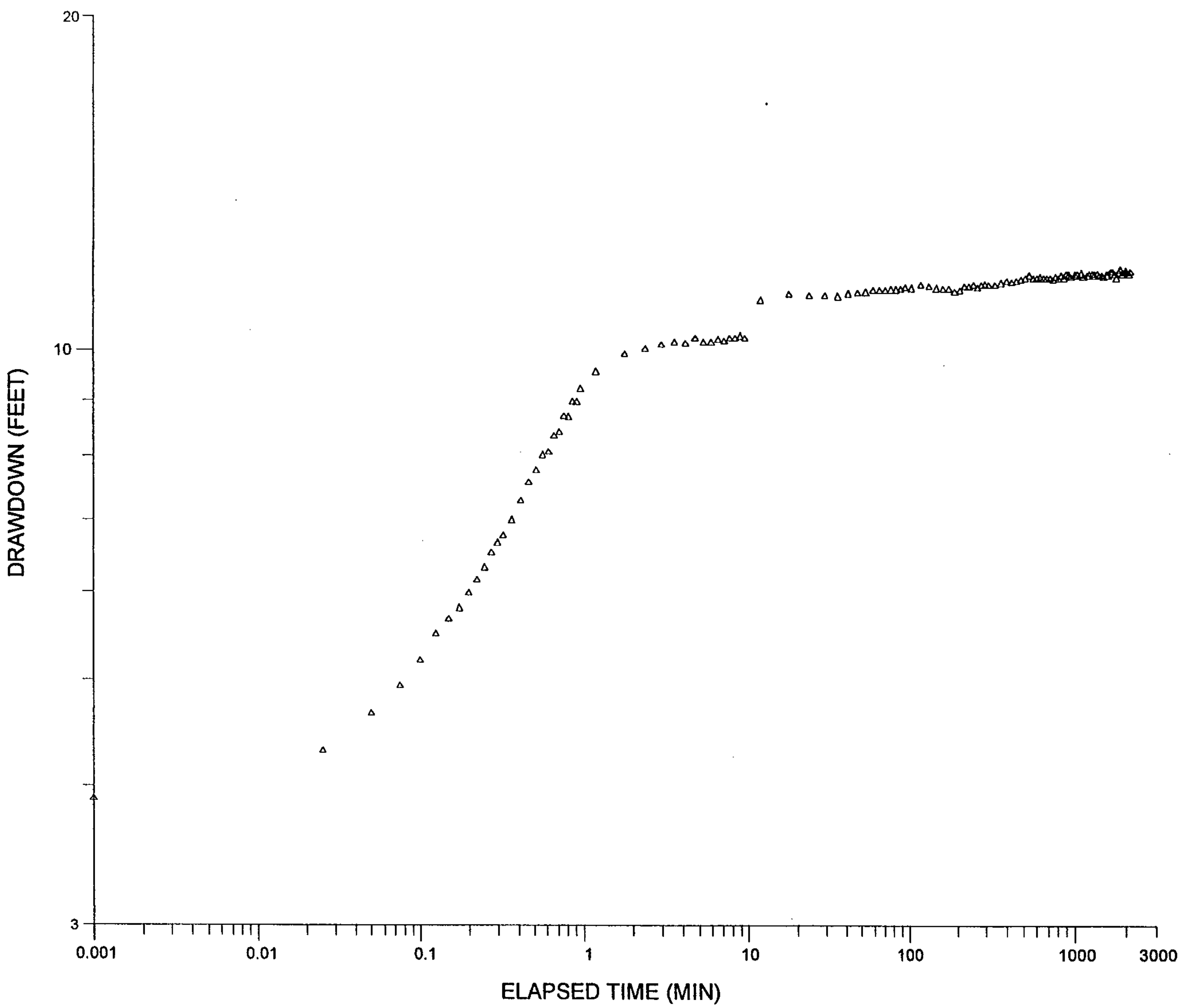

NOTES:

PUMPING RATE IN MWBP-05B IS 16 GPM

FIGURE H-6
CONSTANT RATE TEST RESULTS IN MWBP-05B

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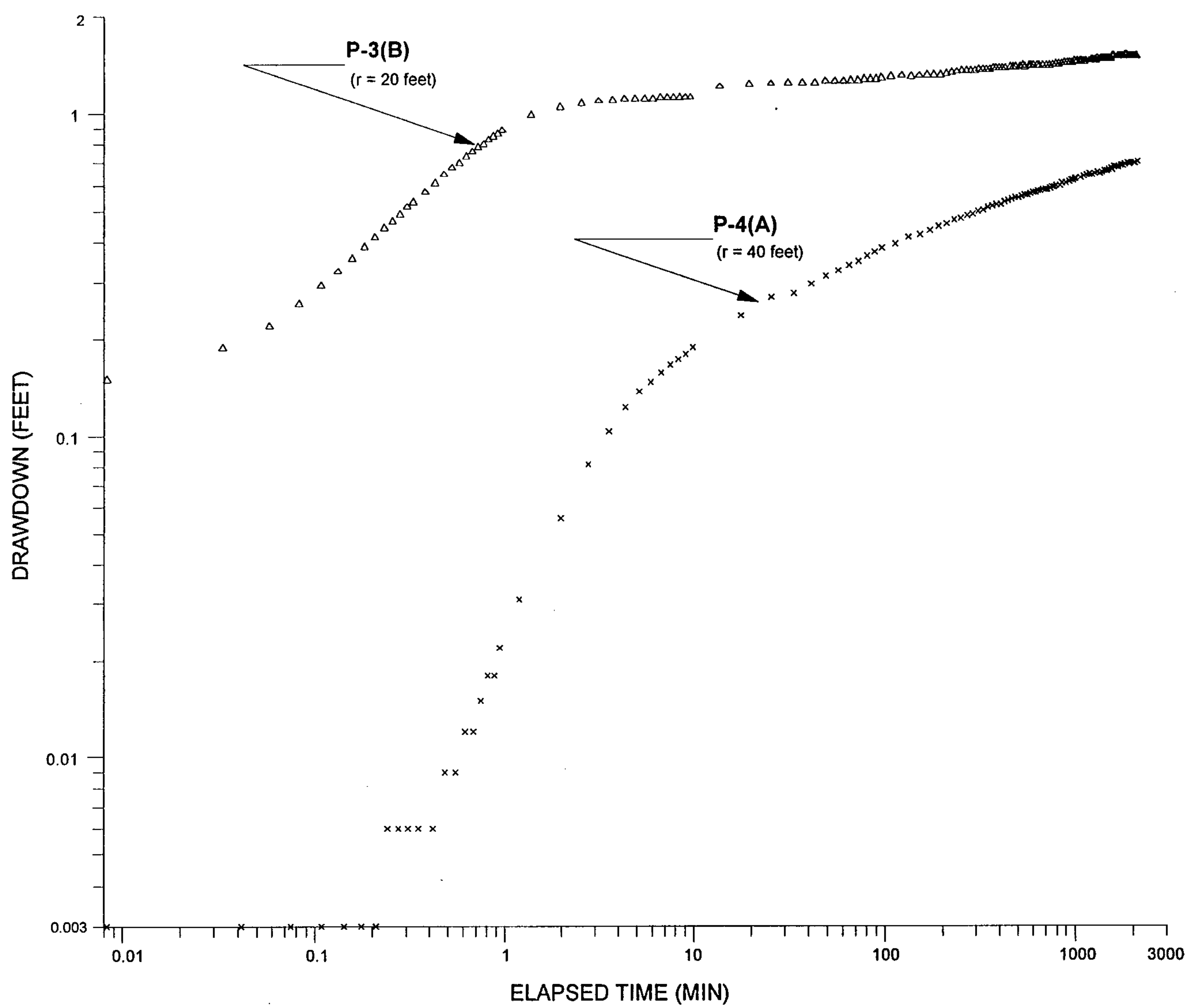

NOTES:

P-3(B) SCREENED AT SAME DEPTH INTERVAL AS MWBP-05B

P-4(A) SCREENED ACROSS THE WATER TABLE

PUMPING RATE IN MWBP-05B IS 16 GPM

DRAWDOWNS HAVE BEEN CORRECTED FOR BACKGROUND FLUCTUATIONS

FIGURE H-7

DRAWDOWN MEASUREMENTS IN P-3(B) AND P-4(A) DURING CONSANT RATE TEST IN MWBP-05B

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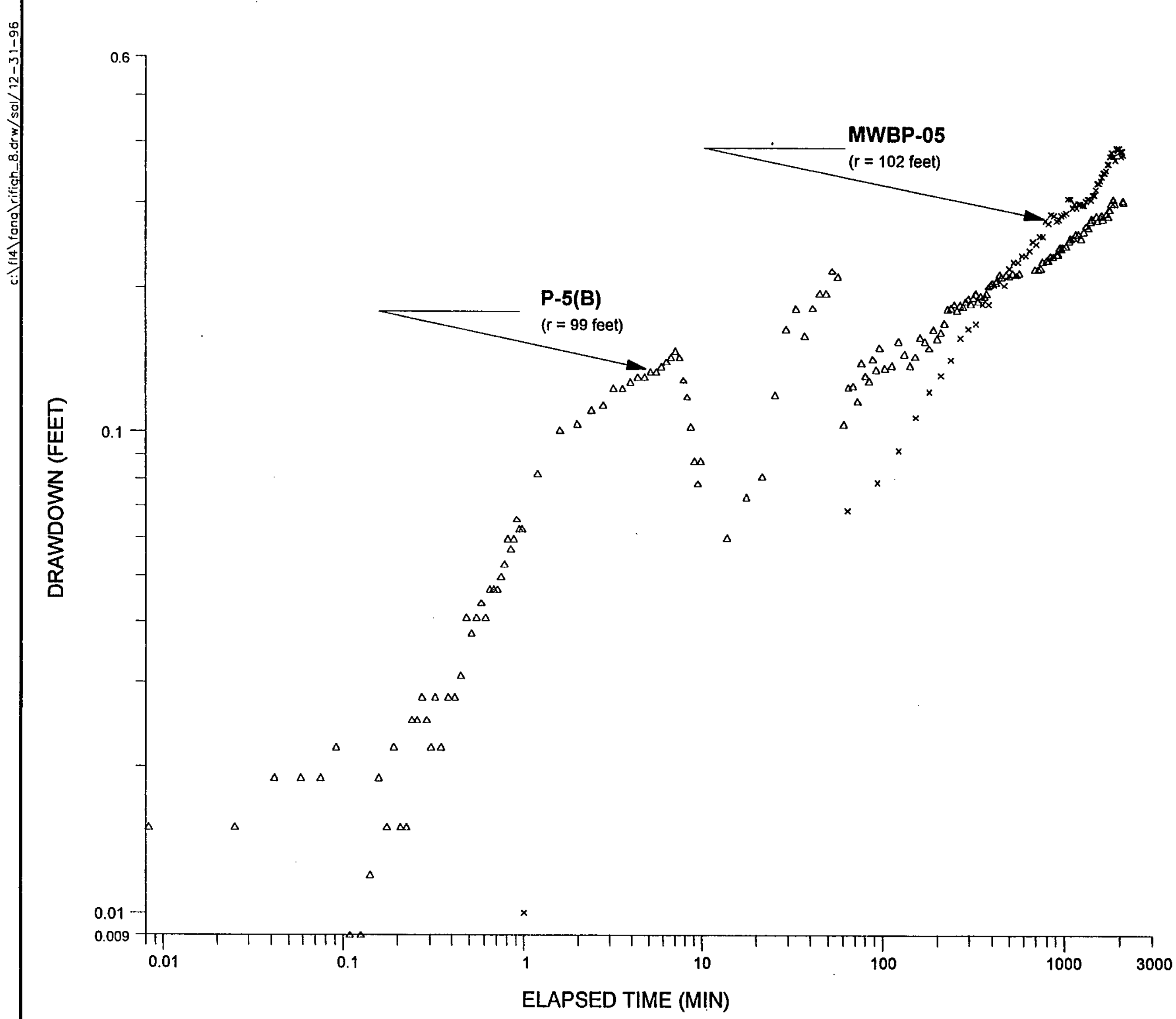

NOTES:

P-5(B) SCREENED AT SAME DEPTH INTERVAL AS MWBP-05B

MWBP-05 SCREENED ACROSS THE WATER TABLE

PUMPING RATE IN MWBP-05B IS 16 GPM

DRAWDOWNS HAVE BEEN CORRECTED FOR BACKGROUND FLUCTUATIONS

FIGURE H-8

DRAWDOWN MEASUREMENTS IN P-5(B) AND MWBP-05 DURING CONSTANT RATE TEST IN MWBP-05B

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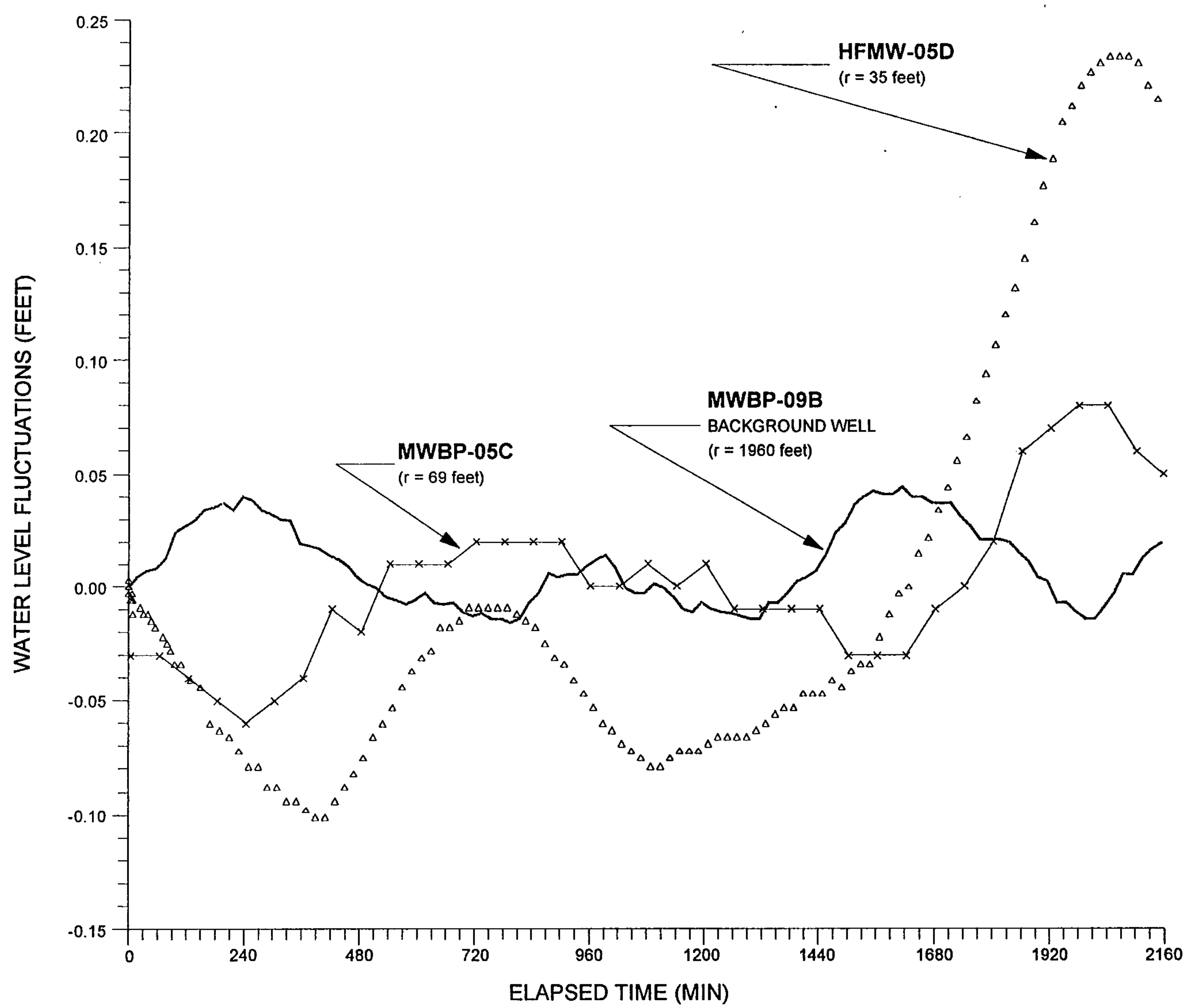

NOTES:

MWBP-09B SCREENED AT SAME DEPTH INTERVAL AS MWBP-05B

MWBP-05C SCREENED 20 FEET BELOW THE BOTTOM OF MWBP-05B

HFMW-05D SCREENED 220 FEET BELOW THE BOTTOM OF MWBP-05B

PUMPING RATE IN MWBP-05B IS 16 GPM

FIGURE H-9

WATER LEVEL FLUCTUATIONS IN MWBP-05C AND HFMW-05D DURING CONSTANT RATE TEST IN MWBP-05B

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1.0 Objective

To estimate aquifer parameters from step-drawdown test recovery data using the method of analysis given in Kawecki (1993).

2.0 Background

Step-drawdown tests were performed in two monitoring wells at the Fresno Air National Guard Base in Fresno, California. The wells tested were MWBP-12 and MWBP-05B. Well MWBP-12 is 4 inches in diameter and is installed to a depth of 92.5 feet below ground surface (bgs). It is screened from 92.5 to 72.5 feet bgs; groundwater occurs at 80.6 feet bgs.

Well MWBP-05B has a diameter of 5 inches and is installed to a depth of 116 feet bgs. It is screened from 116 to 106 feet bgs; groundwater was measured at 80.2 feet bgs at the start of the test.

Traditionally, step-drawdown tests are performed to estimate well efficiencies and specific yields. These analyses are not pertinent in this case because the wells are monitoring wells and were not designed to be extraction/production wells. Step-drawdown tests were run in order to assess the yields of each well for subsequent, more sustained aquifer tests. However, an estimate of the aquifer parameters can be obtained from a fairly recent analysis method published by Kawecki (1993).

2.1 Method

Kawecki states that the popular recovery method of Theis (Theis, 1935; Kruseman and deRidder, 1983) is used to estimate transmissivity by analyzing data from the recovery data from a constant rate discharge test. The equations in the stepped discharge recovery method are a direct extension of the Theis recovery method. If the pump test comprises only one pumping rate and a recovery stage, then the Kawecki method reduces to the Theis recovery method.

Kawecki develops the following equation for residual drawdown (s"):

$$s''(t) = \frac{2.3}{4\pi T}\log[F(t)] \tag{1}$$

where s"(t) is the residual drawdown at any post-pumping time "t" and T is the aquifer transmissivity. The function F(t) is a time function given by:

$$F(t) = \left(\frac{t - t_1}{t - t_2}\right)^{Q_1} \times \left(\frac{t - t_2}{t - t_3}\right)^{Q_2} \times \ldots \times \left(\frac{t - t_{N-1}}{t - t_N}\right)^{Q_{N-1}} \tag{2}$$

Equations (1) and (2) are the basis for the stepped discharge recovery method.

2.2 Explanation

The time function F(t) is calculated for each recovery time, t ($t > t_N$), where a recovery measurement is recorded. Q_1 through Q_{N-1} are the consecutive pumping rates for the test and t_1 through t_{N-1} are the cumulative times at which the pumping rates were changed. The time value for t_1 is the beginning of the

first step, or $t = 0$, and t_2 is the end of step 1 and the beginning of step 2. Q_N is the last pump rate, defined as the recovery period, or in other words, $Q = 0$. Likewise, t_N is the elapsed time from the beginning of the test when the recovery period began. The logarithm_{10} of F(t) is then calculated.

An arithmetic graph of residual drawdown vs corresponding values for $\log_{10}[F(t)]$ is then constructed and a straight line is fitted to the data. The slope of the straight line is calculated; the slope is equal to $(2.3/4\pi T)$. Then the transmissivity is found by:

$$T = \frac{2.3}{4\pi \times slope} \tag{3}$$

2.3 Units

Equation (2) provides F(t) in interesting units. Suppose that the time measurements are in minutes and the pumping rate is in gallons per minute (gpm). The corresponding units are therefore $(\text{min/min})^{gpm}$. When the logarithm is calculated, the units become simply gpm.

The slope from the straight line also has units which bear some clarification. Slope, by definition, is rise/run, or $\Delta y/\Delta x$. The y-value on the plot is the residual drawdown, measured in feet, for example. In order for the units to cancel correctly, the pumping rate must be converted into ft^3/min. This must be done within the F(t) calculations before it is plotted. Then the unit of the slope is equal to $(ft/ft^3/min)$ which is equal to min/ft^2.

The units in Eq. (3) are then resolved into meaningful units for transmissivity.

3.0 Step-Drawdown Tests

Step-drawdown tests were performed in two wells at the Fresno ANG Base in March 1995. Pumping rates and step durations are provided in Table 1. Residual drawdown measurements were collected electronically

Table 1
Step-Drawdown Summary Information

Step No.	Step Duration (min)	Elapsed Time (min)	Flow Rate (gpm)	Flow Rate (ft^3/min)
Well MWBP-12				
1	30	30	2.5	0.334
2	50	80	5	0.669
3	70	150	6.5	0.869
4	60	210	7	0.936
5	NA	NA	0	0
MWBP-05B				
1	44	44	6	0.802
2	130	174	12	1.605
3	70	244	18	2.408
4	24	268	19	2.542
5	NA	NA	0	0

with pressure transducers and a data logger. Graphs of drawdown versus time are included for each well in Attachment 1. Attachment 2 contains the residual drawdown (recovery) data for each test and the spreadsheets with the calculations for F(t) and log[F(t)].

4.0 Example Calculation

The following example for calculating F(t) is taken from the data for MWBP-12 at recovery time 0.1 minutes (min). The total test duration was 210 min, so t_n = 210.1 min and t_1 = 0, t_2 = 30, t_3 = 80, t_4 = 150, and t_5 = 210 min (see Table 1). Step pumping rates are also in Table 1 with Q_1 = Q for step 1, etc. The calculation for F(t) at t_n = 210.1 min is as follows:

$$F(t) = \left(\frac{210.1-0}{210.1-30}\right)^{0.334} \times \left(\frac{210.1-30}{210.1-80}\right)^{0.668} \times \left(\frac{210.1-80}{210.1-150}\right)^{0.869} \times \left(\frac{210.1-150}{210.1-210}\right)^{0.936} \quad (4)$$

Equation 4 reduces to:

$$F(t) = (1.1666)^{0.334} \times (1.3843)^{0.668} \times (2.1647)^{0.869} \times (601.0)^{0.936}$$

$$F(t) = 1.0528 \times 1.2426 \times 1.9564 \times 399.0493 = 1021.32$$

and the log(1021.32) = 3.0092.

This calculation is then performed for each recovery measurement. The spreadsheets in Attachment 2 were developed to perform these calculations. The graph for log[F(t)] vs. residual drawdown for MWBP-12 is shown in Attachment 2; also shown on the graph is the selected straight line fit. The slope of the line is:

$$Slope = \left(\frac{4.5-0.5\ (ft)}{2.78-1.43\ (ft^3/\text{min})}\right) = 2.96\ \text{min}/ft^2$$

From Eq. 3, the transmissivity, T, is 0.062 ft^2/min = 89 ft^2/day.

5.0 Results

Table 2
Summary of Recovery Analysis

Well ID	Slope from Graphs (min/ft^2)	T (ft^2/day)
MWBP-12	2.9~~4~~6	89
MWBP-05B	4.23	62

Attachment 2 contains the recovery data curves, selected straight line fits, slope calculations and T-value calculations.

6.0 Discussion

Once a spreadsheet is developed for handling the tedious F(t) calculations, this method is relatively simple to implement. However, it is highly dependent on the interpretation for the straight line. A linear regression can also be evaluated to provide a second assessment of the slope. These are listed at the end of the spreadsheets in Attachment 2.

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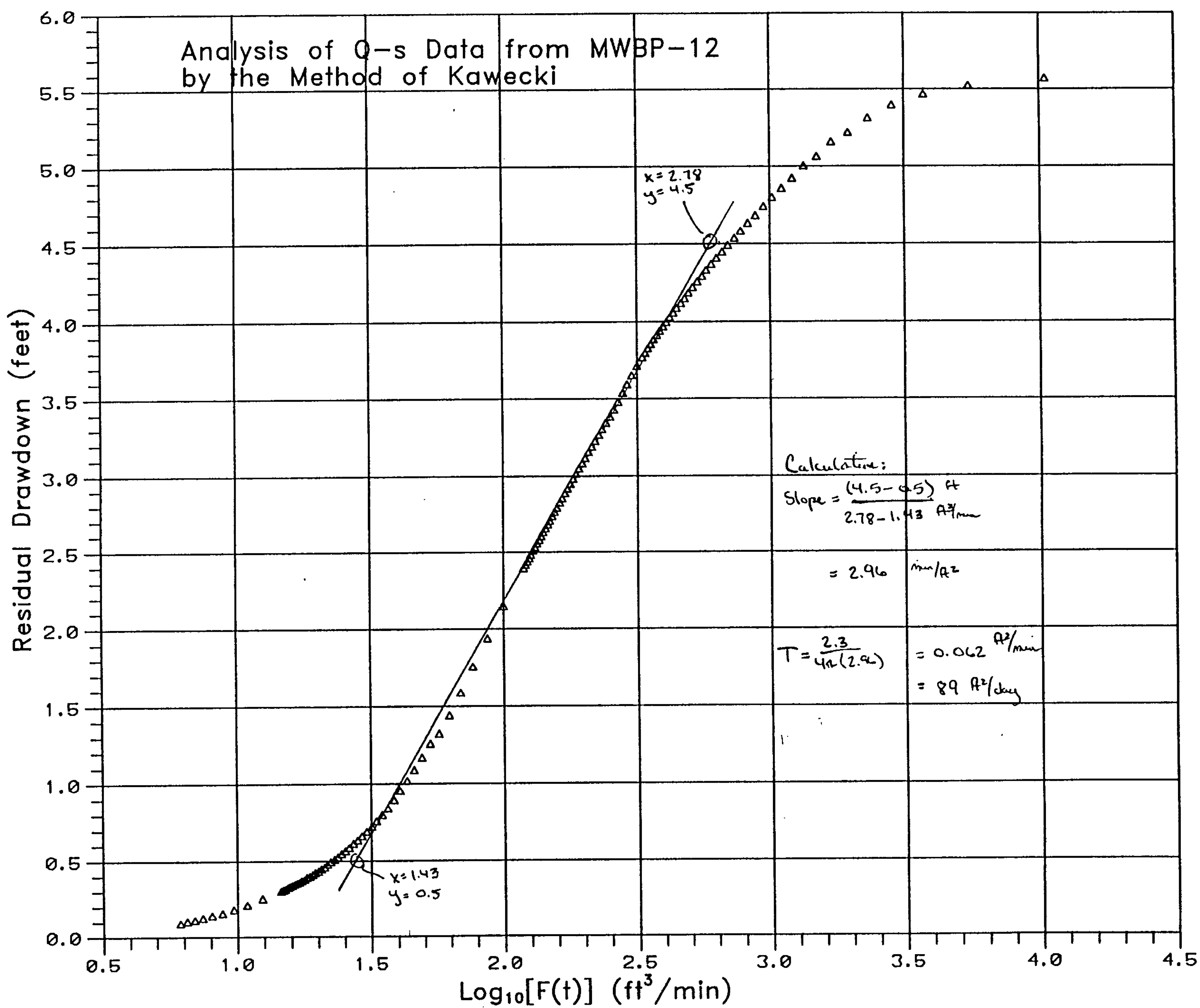
By S. Logan Date 9/8/95 Subject Step-Drawdown Recovery Data Analysis Sheet No. 5 of 5
Chkd. By J. L. Date 9/8/95 Fresno ANG, Wells MWBP-12 and MWBP-05B Proj. No. 409724

7.0 References

Kawecki, M. W., 1993, "Recovery Analysis from Pumping Tests with Stepped Discharge," Groundwater, Vol. 31, No. 4, pp. 585-592.

Kruseman, G. P., N. A. deRidder, 1990, Analysis and Evaluation of Pumping Test Data, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands, Second edition, 377 pp.

Theis, C. V., 1935, The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Groundwater Storage, Transactions, American Geophysical Union, Vol. 16, pp. 519-524.



Analysis of Q–s Data from MWBP-12
by the Method of Kawecki
Residual Drawdown (feet)
$Log_{10}[F(t)]$ (ft^3/min)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
x = 2.78
y = 4.5
x = 1.43
y = 0.5
Calculation:
Slope = $\frac{(4.5-0.5)\ ft}{2.78-1.43\ ft^3/min}$
= 2.96 min/ft²
$T = \frac{2.3}{4\pi(2.96)}$ = 0.062 ft²/min
= 89 ft²/day

Analysis of MWBP-12 Step-Drawdown Recovery Data by the Method of Kawecki

	Pumping Data		
	Elapsed Time (min)	Flow Rate (gpm)	Flow Rate (cu.ft/min)
Q_1, t_1	0	2.5	0.334
Q_2, t_2	30	5	0.668
Q_3, t_3	80	6.5	0.869
Q_4, t_4	150	7	0.936
Q_5, t_5	210	0	0

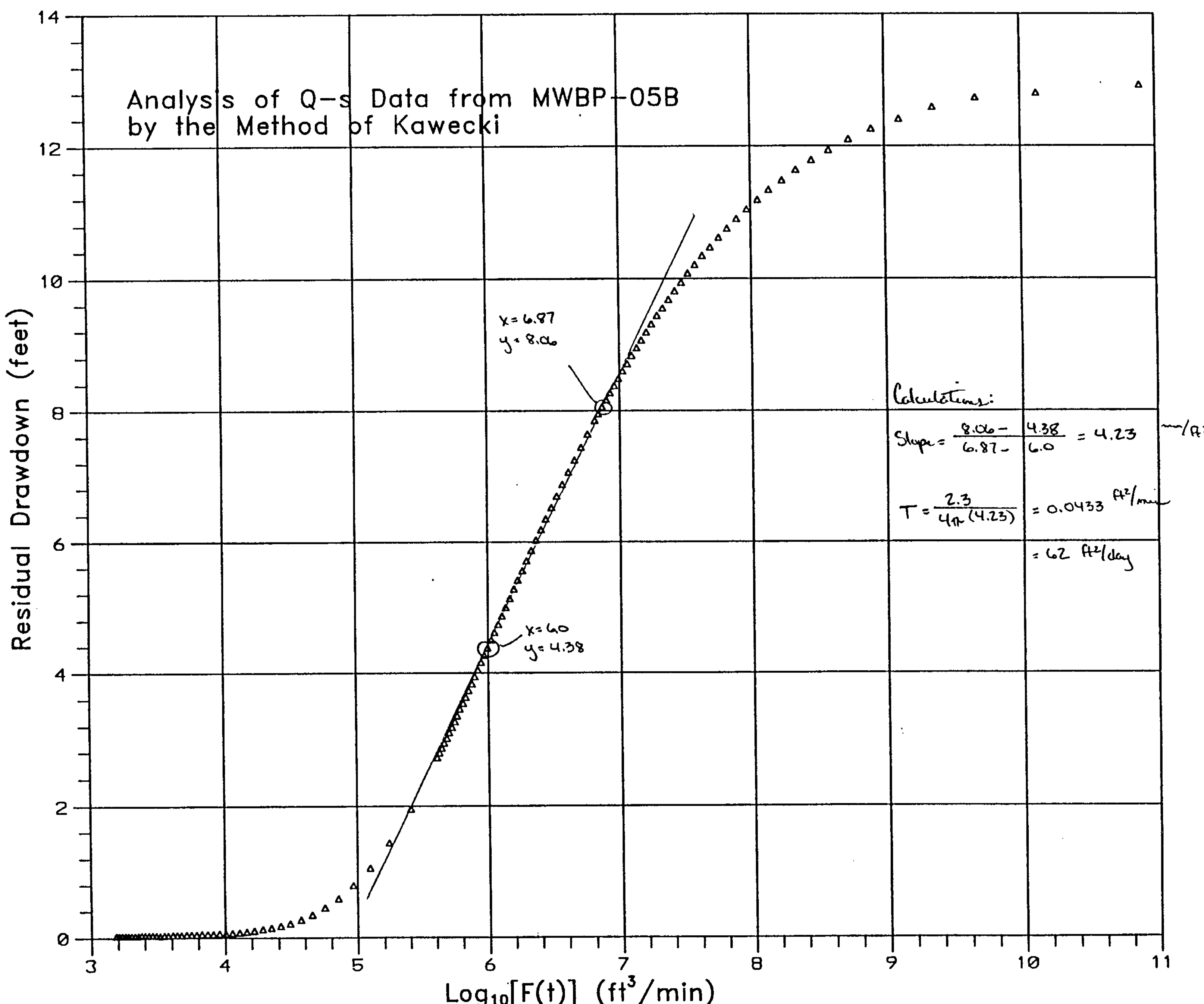
	Recovery Data				
	Elapsed Recovery Time (min)	Residual Drawdown MWBP-12	F(t)	log[F(t)]	Residual Drawdown MWBP-12
0.0083	210.0083	5.572	10487.84	4.0207	5.572
0.0166	210.0166	5.525	5482.061	3.7389	5.525
0.025	210.025	5.468	3736.934	3.5725	5.468
0.0333	210.0333	5.396	2857.601	3.4560	5.396
0.0416	210.0416	5.314	2320.385	3.3656	5.314
0.05	210.05	5.219	1953.519	3.2908	5.219
0.0583	210.0583	5.159	1692.037	3.2284	5.159
0.0666	210.0666	5.065	1493.915	3.1743	5.065
0.075	210.075	5.002	1336.788	3.1261	5.002
0.0833	210.0833	4.923	1211.764	3.0834	4.923
0.0916	210.0916	4.857	1108.74	3.0448	4.857
0.1	210.1	4.8	1021.377	3.0092	4.8
0.1083	210.1083	4.74	947.973	2.9768	4.74
0.1166	210.1166	4.683	884.7088	2.9468	4.683
0.125	210.125	4.633	828.9812	2.9185	4.633
0.1333	210.1333	4.582	780.6088	2.8924	4.582
0.1416	210.1416	4.538	737.7365	2.8679	4.538
0.15	210.15	4.491	699.0324	2.8445	4.491
0.1583	210.1583	4.447	664.7014	2.8226	4.447
0.1666	210.1666	4.409	633.6872	2.8019	4.409
0.175	210.175	4.368	605.2034	2.7819	4.368
0.1833	210.1833	4.33	579.5446	2.7631	4.33
0.1916	210.1916	4.292	556.0409	2.7451	4.292
0.2	210.2	4.258	534.1794	2.7277	4.258
0.2083	210.2083	4.22	514.2568	2.7112	4.22
0.2166	210.2166	4.185	495.8141	2.6953	4.185
0.225	210.225	4.15	478.4919	2.6799	4.15
0.2333	210.2333	4.119	462.5633	2.6652	4.119
0.2416	210.2416	4.087	447.6954	2.6510	4.087
0.25	210.25	4.056	433.6225	2.6371	4.056
0.2583	210.2583	4.028	420.5883	2.6239	4.028
0.2666	210.2666	3.996	408.3405	2.6110	3.996
0.275	210.275	3.968	396.6746	2.5984	3.968
0.2833	210.2833	3.939	385.806	2.5864	3.939
0.2916	210.2916	3.911	375.5369	2.5747	3.911
0.3	210.3	3.883	365.7047	2.5631	3.883

	Elapsed Recovery Time (min)	Recovery Data Residual Drawdown MWBP-12	F(t)	log[F(t)]	Residual Drawdown MWBP-12
0.3083	210.3083	3.854	356.4993	2.5521	3.854
0.3166	210.3166	3.826	347.7617	2.5413	3.826
0.325	210.325	3.797	339.359	2.5307	3.797
0.3333	210.3333	3.769	331.4593	2.5204	3.769
0.35	210.35	3.712	316.6654	2.5006	3.712
0.3666	210.3666	3.652	303.2551	2.4818	3.652
0.3833	210.3833	3.592	290.9002	2.4637	3.592
0.4	210.4	3.536	279.5454	2.4465	3.536
0.4166	210.4166	3.479	269.1332	2.4300	3.479
0.4333	210.4333	3.428	259.4385	2.4140	3.428
0.45	210.45	3.384	250.4412	2.3987	3.384
0.4666	210.4666	3.343	242.1165	2.3840	3.343
0.4833	210.4833	3.302	234.3008	2.3698	3.302
0.5	210.5	3.265	226.9912	2.3560	3.265
0.5166	210.5166	3.227	220.1792	2.3428	3.227
0.5333	210.5333	3.189	213.7408	2.3299	3.189
0.55	210.55	3.154	207.6814	2.3174	3.154
0.5666	210.5666	3.116	202.0012	2.3054	3.116
0.5833	210.5833	3.082	196.603	2.2936	3.082
0.6	210.6	3.047	191.4959	2.2822	3.047
0.6166	210.6166	3.012	186.6851	2.2711	3.012
0.6333	210.6333	2.981	182.0918	2.2603	2.981
0.65	210.65	2.946	177.7273	2.2498	2.946
0.6666	210.6666	2.914	173.5989	2.2395	2.914
0.6833	210.6833	2.883	169.6417	2.2295	2.883
0.7	210.7	2.851	165.8675	2.2198	2.851
0.7166	210.7166	2.823	162.2848	2.2103	2.823
0.7333	210.7333	2.788	158.839	2.2010	2.788
0.75	210.75	2.76	155.542	2.1918	2.76
0.7666	210.7666	2.732	152.4026	2.1830	2.732
0.7833	210.7833	2.703	149.3743	2.1743	2.703
0.8	210.8	2.678	146.4686	2.1657	2.678
0.8166	210.8166	2.653	143.6944	2.1574	2.653
0.8333	210.8333	2.628	141.0115	2.1493	2.628
0.85	210.85	2.602	138.4307	2.1412	2.602
0.8666	210.8666	2.577	135.9609	2.1334	2.577
0.8833	210.8833	2.555	133.5669	2.1257	2.555
0.9	210.9	2.53	131.2591	2.1181	2.53
0.9166	210.9166	2.508	129.0457	2.1107	2.508
0.9333	210.9333	2.482	126.896	2.1034	2.482
0.95	210.95	2.46	124.8196	2.0963	2.46
0.9666	210.9666	2.438	122.8244	2.0893	2.438
0.9833	210.9833	2.416	120.8831	2.0824	2.416
1	211	2.394	119.0046	2.0756	2.394
1.2	211.2	2.145	100.456	2.0020	2.145
1.4	211.4	1.94	87.06408	1.9398	1.94
1.6	211.6	1.757	76.92774	1.8861	1.757

	Elapsed Recovery Time (min)	Recovery Data Residual Drawdown MWBP-12	F(t)	log[F(t)]	Residual Drawdown MWBP-12
1.8	211.8	1.587	68.98073	1.8387	1.587
2	212	1.441	62.57798	1.7964	1.441
2.2	212.2	1.325	57.30598	1.7582	1.325
2.4	212.4	1.259	52.88726	1.7234	1.259
2.6	212.6	1.17	49.12856	1.6913	1.17
2.8	212.8	1.091	45.89113	1.6617	1.091
3	213	1.019	43.07269	1.6342	1.019
3.2	213.2	0.956	40.59617	1.6085	0.956
3.4	213.4	0.896	38.4024	1.5844	0.896
3.6	213.6	0.842	36.44516	1.5616	0.842
3.8	213.8	0.801	34.68783	1.5402	0.801
4	214	0.76	33.10102	1.5198	0.76
4.2	214.2	0.722	31.66082	1.5005	0.722
4.4	214.4	0.691	30.34765	1.4821	0.691
4.6	214.6	0.662	29.14527	1.4646	0.662
4.8	214.8	0.634	28.04008	1.4478	0.634
5	215	0.612	27.02067	1.4317	0.612
5.2	215.2	0.586	26.07733	1.4163	0.586
5.4	215.4	0.564	25.20178	1.4014	0.564
5.6	215.6	0.545	24.38689	1.3872	0.545
5.8	215.8	0.523	23.62652	1.3734	0.523
6	216	0.508	22.91533	1.3601	0.508
6.2	216.2	0.492	22.24864	1.3473	0.492
6.4	216.4	0.476	21.62237	1.3349	0.476
6.6	216.6	0.46	21.03292	1.3229	0.46
6.8	216.8	0.448	20.47711	1.3113	0.448
7	217	0.432	19.95211	1.3000	0.432
7.2	217.2	0.422	19.45539	1.2890	0.422
7.4	217.4	0.41	18.98473	1.2784	0.41
7.6	217.6	0.397	18.53809	1.2681	0.397
7.8	217.8	0.391	18.11368	1.2580	0.391
8	218	0.378	17.70984	1.2482	0.378
8.2	218.2	0.369	17.32512	1.2387	0.369
8.4	218.4	0.359	16.95817	1.2294	0.359
8.6	218.6	0.353	16.60778	1.2203	0.353
8.8	218.8	0.347	16.27284	1.2115	0.347
9	219	0.34	15.95234	1.2028	0.34
9.2	219.2	0.331	15.64536	1.1944	0.331
9.4	219.4	0.325	15.35105	1.1861	0.325
9.6	219.6	0.315	15.06864	1.1781	0.315
9.8	219.8	0.309	14.79741	1.1702	0.309
10	220	0.302	14.53671	1.1625	0.302
12	222	0.252	12.39487	1.0932	0.252
14	224	0.211	10.84931	1.0354	0.211
16	226	0.183	9.680078	0.9859	0.183
18	228	0.157	8.763837	0.9427	0.157
20	230	0.142	8.025986	0.9045	0.142

	Recovery Data					
	Elapsed Recovery Time (min)	Residual Drawdown MWBP-12	F(t)	log[F(t)]	Residual Drawdown MWBP-12
22	232	0.126	7.418717	0.8703	0.126
24	234	0.113	6.909955	0.8395	0.113
26	236	0.104	6.477369	0.8114	0.104
28	238	0.091	6.104925	0.7857	0.091

$$F(t) = [(t_n-t_1)/(t_n-t_2)^{Q_1} \times (t_n-t_2)/(t_n-t_3)^{Q_2} \times (t_n-t_3)/(t_n-t_4)^{Q_3} \times (t_n-t_4)/(t_n-t_5)^{Q_4}]$$


Analysis of Q-s Data from MWBP-05B
by the Method of Kawecki
Residual Drawdown (feet)
$\mathrm{Log_{10}[F(t)]}$ ($\mathrm{ft^3/min}$)
x = 6.87
y = 8.06
x = 6.0
y = 4.38
Calculations:
Slope = $\frac{8.06 - 4.38}{6.87 - 6.0}$ = 4.23 m/ft2
T = $\frac{2.3}{4\pi(4.23)}$ = 0.0433 ft2/min
= 62 ft2/day

Analysis of MWBP-05B Step-Drawdown Recovery Data by the Method of Kawecki

Pumping Data

	Elapsed Time (min)	Flow Rate (gpm)	Flow Rate (cu.ft/min)
Q_1, t_1	0	6	0.802
Q_2, t_2	44	12	1.604
Q_3, t_3	174	18	2.406
Q_4, t_4	244	19	2.54
Q_5, t_5	268	0	0

Recovery Data

	Elapsed Recovery Time (min)	Residual Drawdown MWBP-05B	F(t)	log[F(t)]	Residual Drawdown MWBP-05B
0.0083	268.0083	12.923	7.68E+10	10.88528	12.923
0.0166	268.0166	12.803	1.32E+10	10.12073	12.803
0.025	268.025	12.727	4.67E+09	9.669117	12.727
0.0333	268.0333	12.587	2.25E+09	9.352951	12.587
0.0416	268.0416	12.403	1.28E+09	9.107536	12.403
0.05	268.05	12.257	8.03E+08	8.904725	12.257
0.0583	268.0583	12.099	5.44E+08	8.735385	12.099
0.0666	268.0666	11.934	3.88E+08	8.588633	11.934
0.075	268.075	11.782	2.87E+08	8.457678	11.782
0.0833	268.0833	11.636	2.2E+08	8.341969	11.636
0.0916	268.0916	11.477	1.73E+08	8.237268	11.477
0.1	268.1	11.332	1.38E+08	8.140558	11.332
0.1083	268.1083	11.186	1.13E+08	8.052676	11.186
0.1166	268.1166	11.04	93603509	7.971292	11.04
0.125	268.125	10.894	78456754	7.89463	10.894
0.1333	268.1333	10.754	66648073	7.823788	10.754
0.1416	268.1416	10.615	57178126	7.75723	10.615
0.15	268.15	10.475	49400810	7.693734	10.475
0.1583	268.1583	10.342	43092205	7.634399	10.342
0.1666	268.1666	10.209	37852984	7.5781	10.209
0.175	268.175	10.075	33412827	7.523913	10.075
0.1833	268.1833	9.942	29707873	7.472872	9.942
0.1916	268.1916	9.815	26551800	7.424094	9.815
0.2	268.2	9.682	23814287	7.376838	9.682
0.2083	268.2083	9.555	21481141	7.332057	9.555
0.2166	268.2166	9.435	19454942	7.28903	9.435
0.225	268.225	9.308	17665828	7.247134	9.308
0.2333	268.2333	9.187	16115673	7.207248	9.187
0.2416	268.2416	9.067	14748911	7.16876	9.067
0.25	268.25	8.952	13524888	7.131134	8.952
0.2583	268.2583	8.832	12450293	7.09518	8.832
0.2666	268.2666	8.717	11491191	7.060365	8.717
0.275	268.275	8.603	10622333	7.02622	8.603
0.2833	268.2833	8.489	9851285	6.993493	8.489
0.2916	268.2916	8.381	9156154	6.961713	8.381
0.3	268.3	8.273	8520410	6.93046	8.273
0.3083	268.3083	8.165	7951149	6.90043	8.165
0.3166	268.3166	8.057	7433599	6.871199	8.057

	Elapsed Recovery Time (min)	Recovery Data Residual Drawdown MWBP-05B	F(t)	log[F(t)]	Residual Drawdown MWBP-05B
0.325	268.325	7.949	6956458	6.842388	7.949
0.3333	268.3333	7.848	6525960	6.814644	7.848
0.35	268.35	7.645	5765838	6.760862	7.645
0.3666	268.3666	7.442	5127370	6.709895	7.442
0.3833	268.3833	7.245	4580406	6.660904	7.245
0.4	268.4	7.061	4111585	6.614009	7.061
0.4166	268.4166	6.876	3709393	6.569303	6.876
0.4333	268.4333	6.699	3358115	6.526096	6.699
0.45	268.45	6.521	3051602	6.484528	6.521
0.4666	268.4666	6.349	2784300	6.444716	6.349
0.4833	268.4833	6.184	2547264	6.406074	6.184
0.5	268.5	6.025	2337489	6.36875	6.025
0.5166	268.5166	5.867	2152133	6.332869	5.867
0.5333	268.5333	5.714	1985739	6.297922	5.714
0.55	268.55	5.562	1836781	6.264057	5.562
0.5666	268.5666	5.416	1703743	6.231404	5.416
0.5833	268.5833	5.276	1583104	6.199509	5.276
0.6	268.6	5.136	1474075	6.168519	5.136
0.6166	268.6166	5.003	1375822	6.138562	5.003
0.6333	268.6333	4.869	1285972	6.109232	4.869
0.65	268.65	4.742	1204116	6.080668	4.742
0.6666	268.6666	4.621	1129790	6.052998	4.621
0.6833	268.6833	4.501	1061332	6.025851	4.501
0.7	268.7	4.38	998535.2	5.999363	4.38
0.7166	268.7166	4.266	941145.4	5.973657	4.266
0.7333	268.7333	4.158	887958.3	5.948393	4.158
0.75	268.75	4.043	838881.5	5.923701	4.043
0.7666	268.7666	3.942	793777.4	5.899699	3.942
0.7833	268.7833	3.834	751751.3	5.876074	3.834
0.8	268.8	3.738	712772.9	5.852951	3.738
0.8166	268.8166	3.637	676773.1	5.830443	3.637
0.8333	268.8333	3.541	643071.6	5.808259	3.541
0.85	268.85	3.452	611672.2	5.786519	3.452
0.8666	268.8666	3.357	582546.2	5.76533	3.357
0.8833	268.8833	3.268	555166	5.744423	3.268
0.9	268.9	3.185	529553.2	5.72391	3.185
0.9166	268.9166	3.103	505703.2	5.703896	3.103
0.9333	268.9333	3.02	483199.2	5.684126	3.02
0.95	268.95	2.944	462072.4	5.66471	2.944
0.9666	268.9666	2.867	442331.5	5.645748	2.867
0.9833	268.9833	2.791	423642.8	5.627	2.791
1	269	2.721	406041.1	5.60857	2.721
1.2	269.2	1.958	256574.9	5.409214	1.958
1.4	269.4	1.437	174151.9	5.240928	1.437
1.6	269.6	1.055	124561	5.095382	1.055
1.8	269.8	0.788	92726.16	4.967202	0.788
2	270	0.591	71239.44	4.85272	0.591
2.2	270.2	0.451	56146.14	4.74932	0.451
2.4	270.4	0.343	45192.71	4.655068	0.343
2.6	270.6	0.273	37025.32	4.568499	0.273

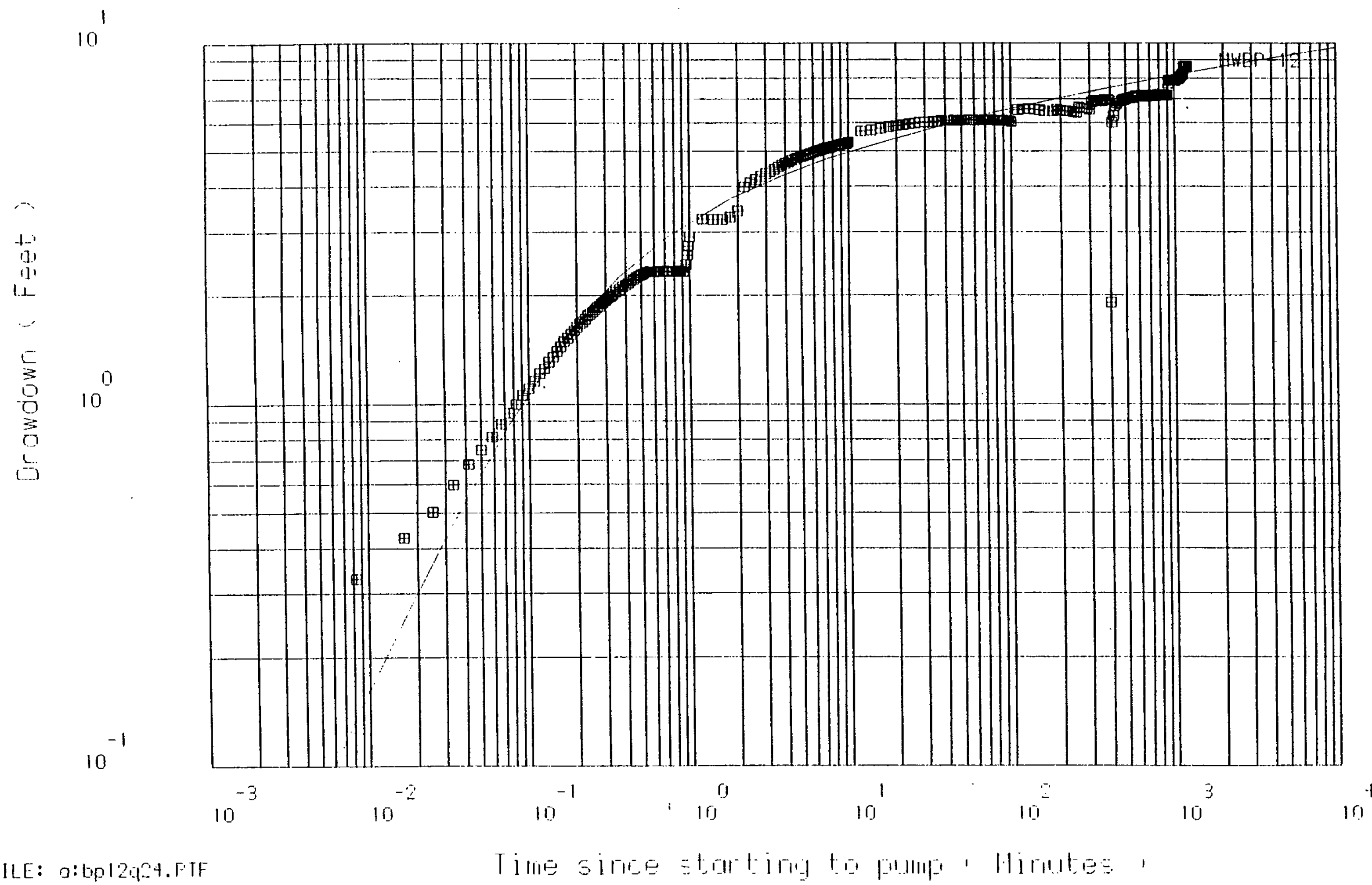
	Elapsed Recovery Time (min)	Recovery Data Residual Drawdown MWBP-05B	F(t)	log[F(t)]	Residual Drawdown MWBP-05B
2.8	270.8	0.216	30794.32	4.488471	0.216
3	271	0.178	25946.56	4.41408	0.178
3.2	271.2	0.152	22110.44	4.344597	0.152
3.4	271.4	0.127	19029.5	4.279427	0.127
3.6	271.6	0.108	16522.51	4.218076	0.108
3.8	271.8	0.095	14458.71	4.16013	0.095
4	272	0.082	12742.02	4.105238	0.082
4.2	272.2	0.076	11300.64	4.053103	0.076
4.4	272.4	0.069	10080.16	4.003467	0.069
4.6	272.6	0.063	9038.749	3.956108	0.063
4.8	272.8	0.057	8143.889	3.910832	0.057
5	273	0.057	7369.999	3.867467	0.057
5.2	273.2	0.057	6696.761	3.825865	0.057
5.4	273.4	0.05	6107.881	3.785891	0.05
5.6	273.6	0.05	5590.183	3.747426	0.05
5.8	273.8	0.05	5132.925	3.710365	0.05
6	274	0.044	4727.285	3.674612	0.044
6.2	274.2	0.044	4365.968	3.640081	0.044
6.4	274.4	0.044	4042.903	3.606693	0.044
6.6	274.6	0.038	3753.009	3.57438	0.038
6.8	274.8	0.038	3492.006	3.543075	0.038
7	275	0.031	3256.273	3.512721	0.031
7.2	275.2	0.038	3042.729	3.483263	0.038
7.4	275.4	0.038	2848.741	3.454653	0.038
7.6	275.6	0.038	2672.05	3.426845	0.038
7.8	275.8	0.038	2510.708	3.399796	0.038
8	276	0.038	2363.03	3.373469	0.038
8.2	276.2	0.031	2227.553	3.347828	0.031
8.4	276.4	0.031	2102.999	3.322839	0.031
8.6	276.6	0.031	1988.253	3.298472	0.031
8.8	276.8	0.031	1882.336	3.274697	0.031
9	277	0.031	1784.385	3.251489	0.031
9.2	277.2	0.031	1693.64	3.228821	0.031
9.4	277.4	0.031	1609.426	3.206671	0.031
9.6	277.6	0.031	1531.146	3.185017	0.031

$$F(t) = [(t_n-t_1)/(t_n-t_2)^{Q_1} \times (t_n-t_2)/(t_n-t_3)^{Q_2} \times (t_n-t_3)/(t_n-t_4)^{Q_3} \times (t_n-t_4)/(t_n-t_5)^{Q_4}]$$

[PUMPING TEST LOG-LOG ANALYSIS : Papadopulos & Cooper TYPE CURVE 0.1]

Pumping well	: MWBP-12		
Pumping rate	Q =	7.5000 USG/Min	
Radius of casing	rc =	0.5000 FT	
Radius of well bore	rw =	0.1600 FT	
	Alfa =	0.10000	

Transmissivity	T =	1258.394 USGPD/FT	
Storativity	S =	0.06594348	
Stor. [Alfa*rc^2/rw^2]	S2 =	0.97656250	
MATCH POINT :			
1/uw	=	276.80	1.00
F(uw,Alfa)	=	1.4641000	1.00
Time	=	1.00	0.0036127 Min
Drawdown	=	1.00	0.6830135 FT



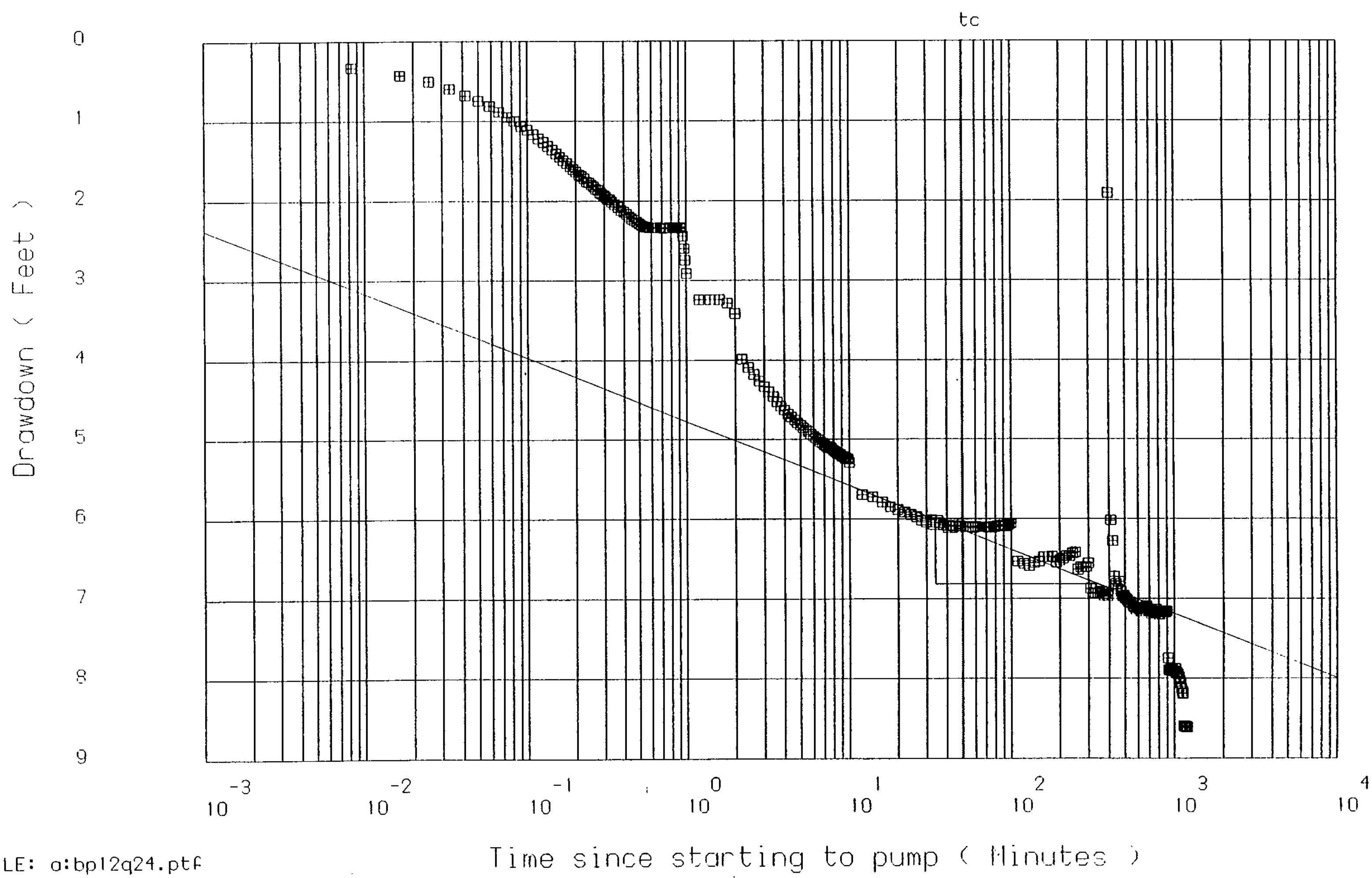
FILE: a:bp12q24.PTF

[PUMPING TEST SEMI-LOG ANALYSIS : JACOB METHOD]

Pumping well : MWBP-12

Pumping rate Q = 7.5000 USG/Min

t0	=	0.00000115 Min
ds	=	0.80418110 FT
T	=	2458.038 USGPD/FT
rc	=	0.5000 FT
rp	=	0.1600 FT
tc	=	49.298 Min



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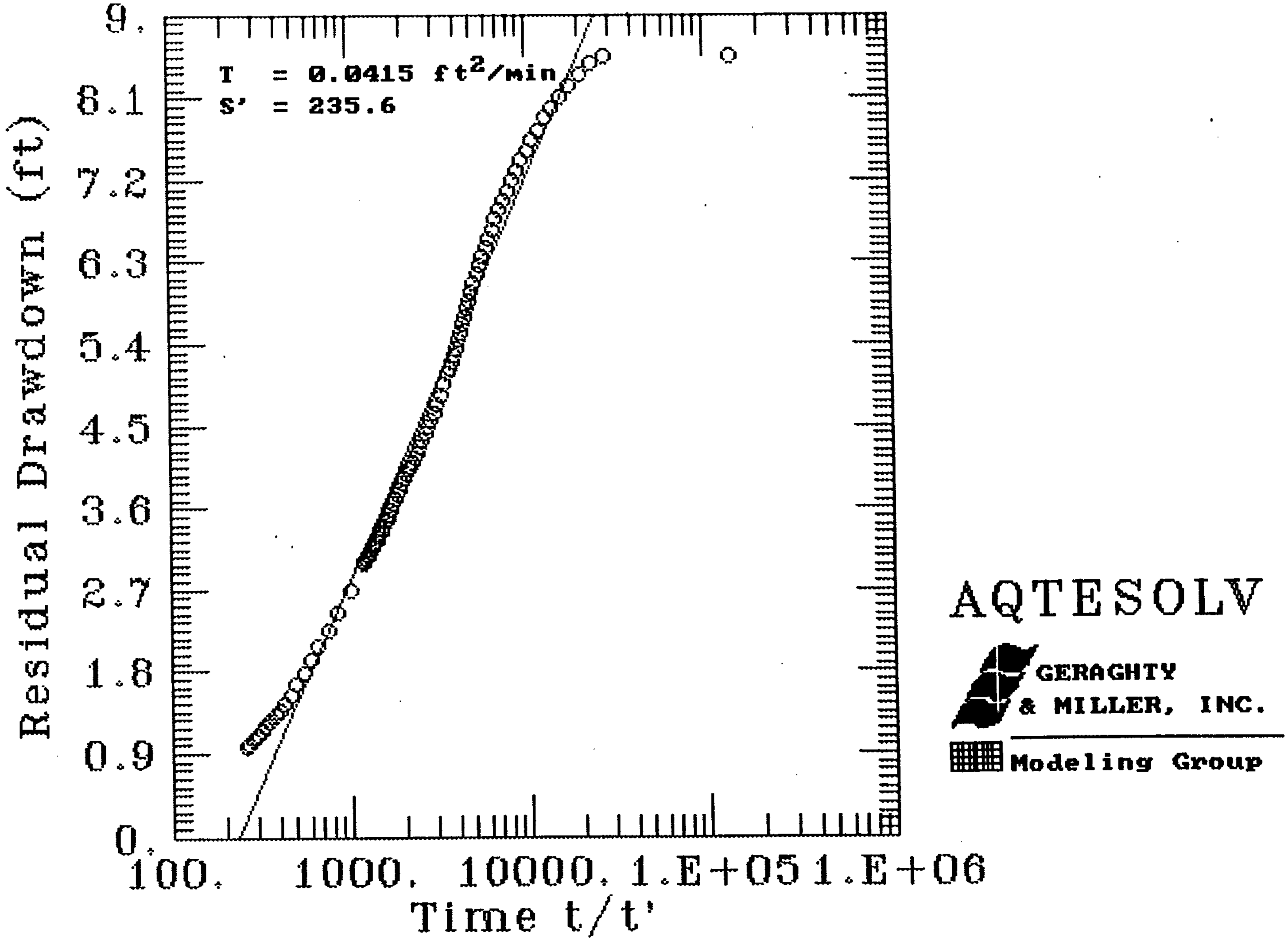
FRESNO ANG MWBP-12 RECOVERY TEST



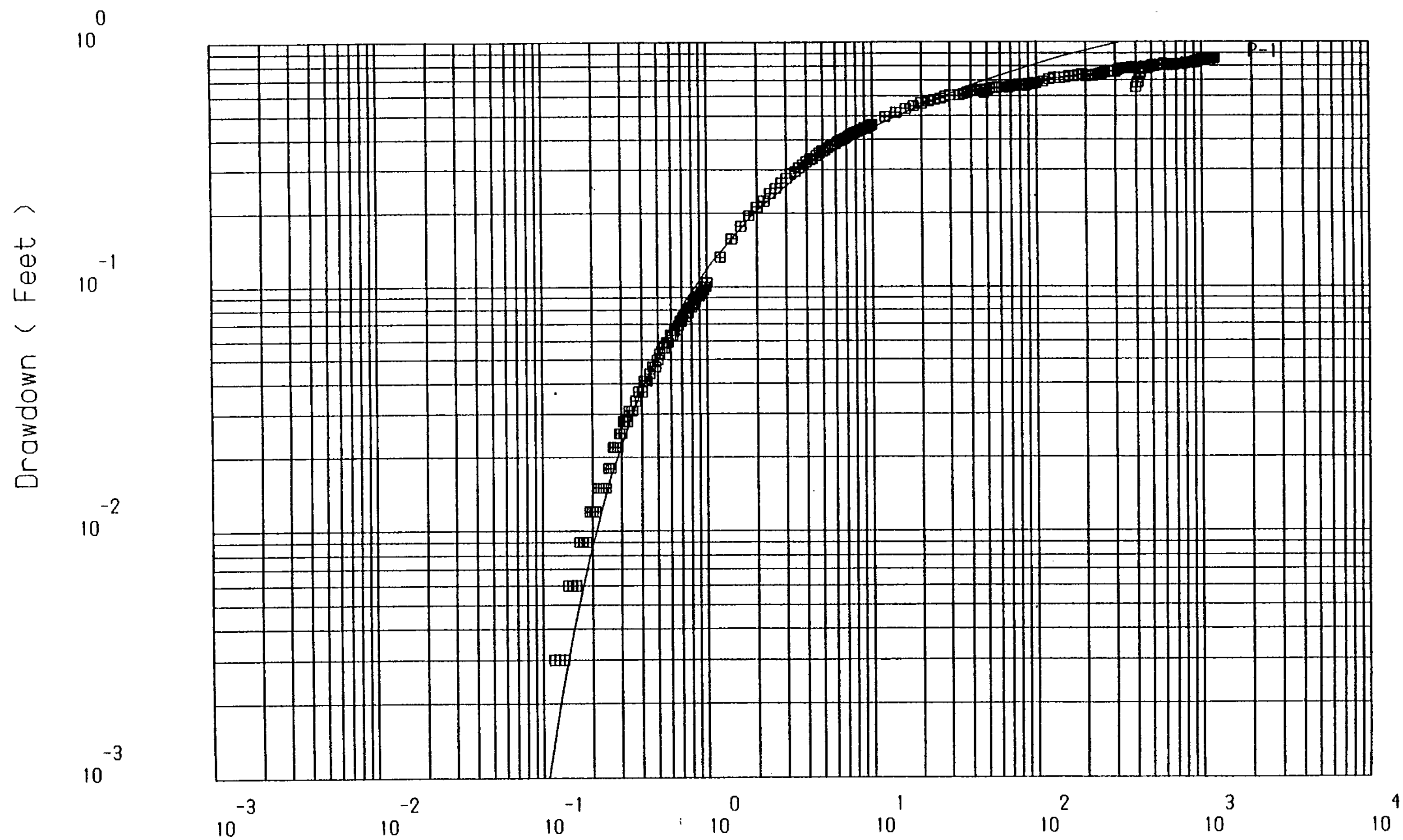
[PUMPING TEST LOG-LOG ANALYSIS : Rtheis TYPE CURVE Confined]

Observation well	:	P-1
Distance	r =	15.00 FT
Pumping well	:	MWBP-12
Pumping rate	Q =	7.5000 USG/Min
Aquifer thickness	b =	8.0000 FT

Transmissivity	T =	5256.624 USGPD/FT
Storativity	S =	0.00334473
Hydr. conductivity	K =	657.078 USGPD/FT^2

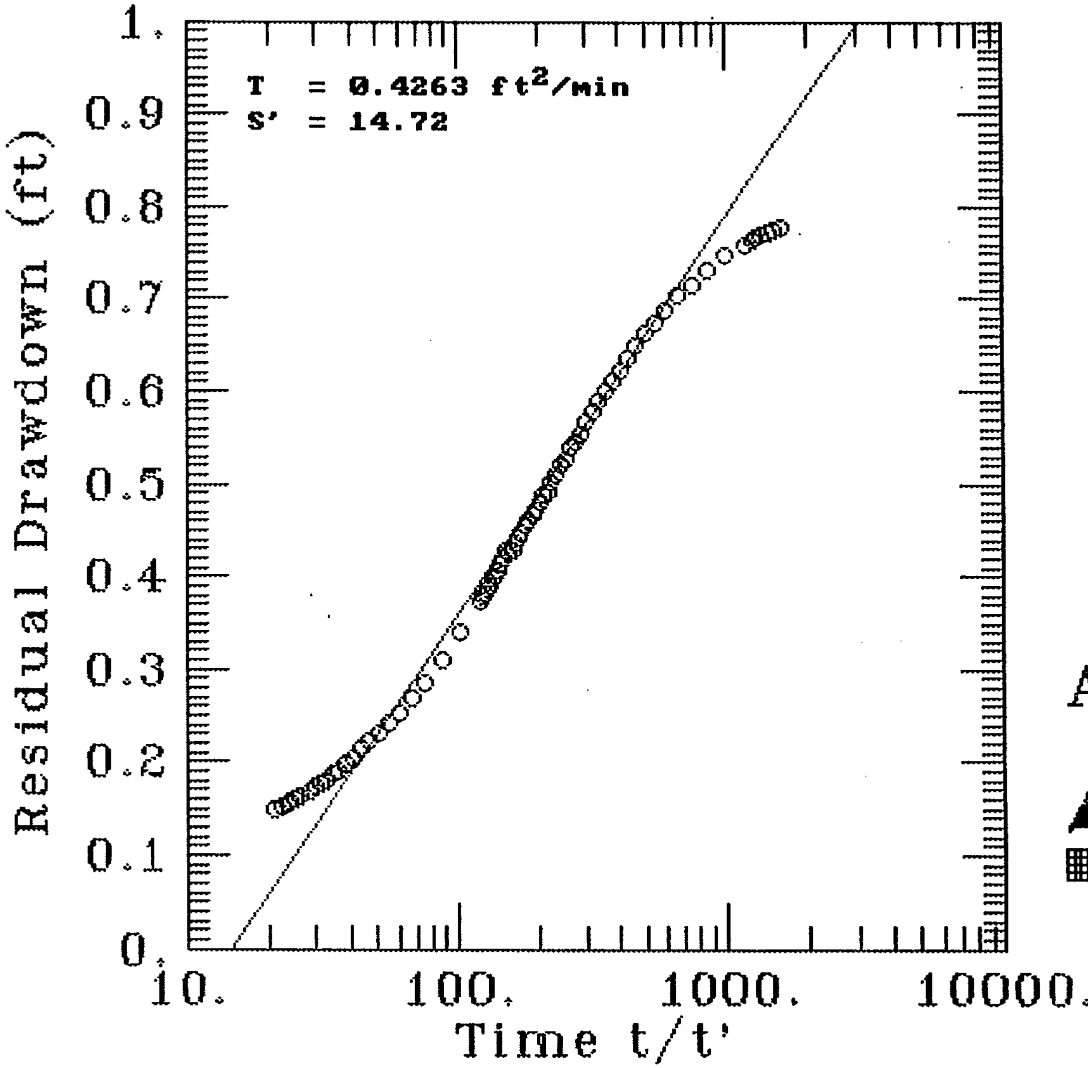
MATCH POINT :

1/u	=	2.5937425	1.00
W(u)	=	6.1159090	1.00
Time	=	1.00	0.3855433 Min
Drawdown	=	1.00	0.1635080 FT



FILE: a:bp12q24.PTF

FRESNO ANG P-1 RECOVERY TEST



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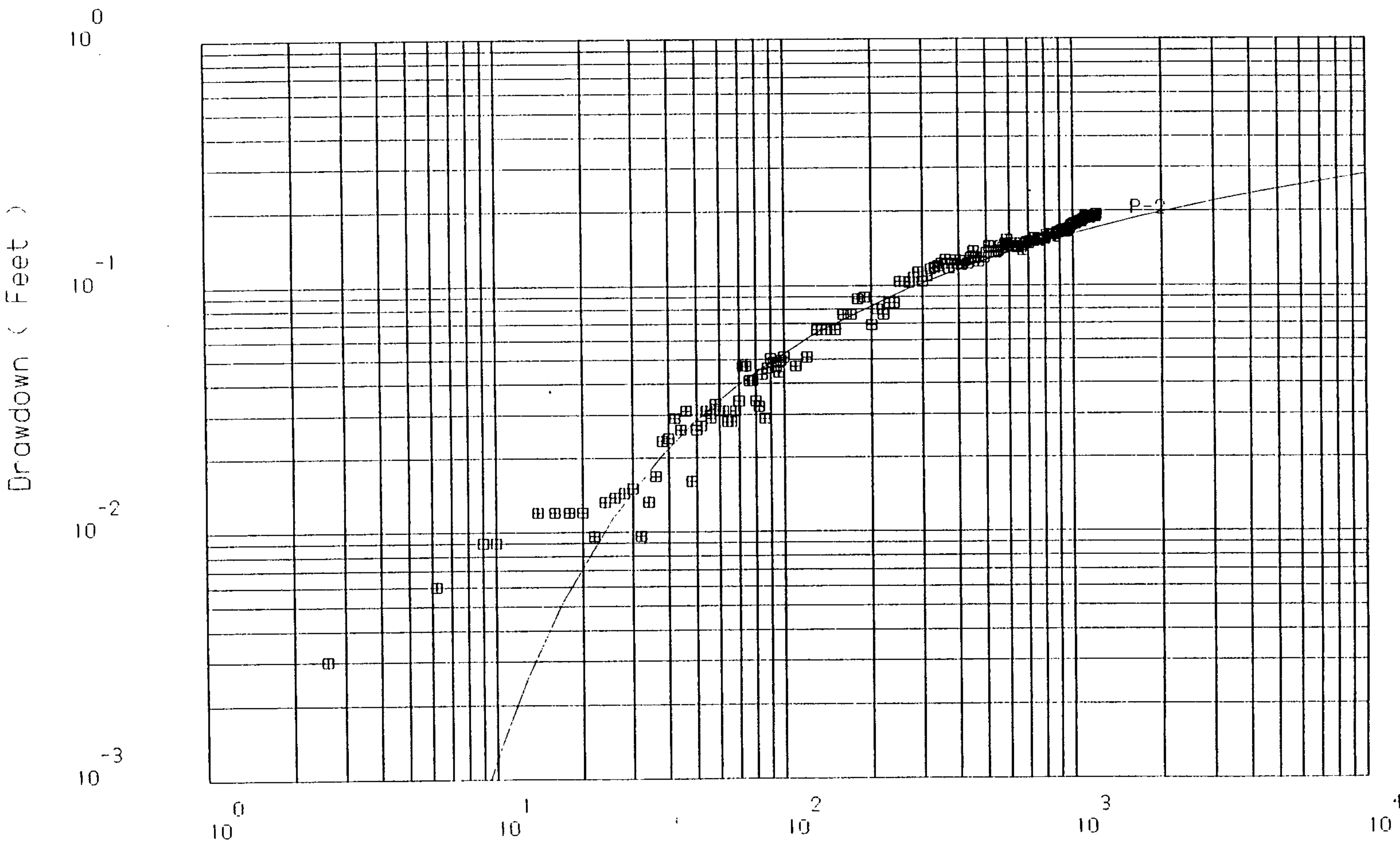
Modeling Group

[PUMPING TEST LOG-LOG ANALYSIS : Rtheis TYPE CURVE Confined]

Observation well	: P-2	
Distance	r =	50.00 FT
Pumping well	: MWBP-12	
Pumping rate	Q =	7.5000 USG/Min
Aquifer thickness	b =	8.0000 FT

Transmissivity	T =	16497.537 USGPD/FT	
Storativity	S =	0.06260284	
Hydr. conductivity	K =	2062.192 USGPD/FT^2	
MATCH POINT :			
1/u	=	0.0391425	1.00
W(u)	=	19.19	1.00
Time	=	1.00	25.55 Min
Drawdown	=	1.00	0.0520987 FT



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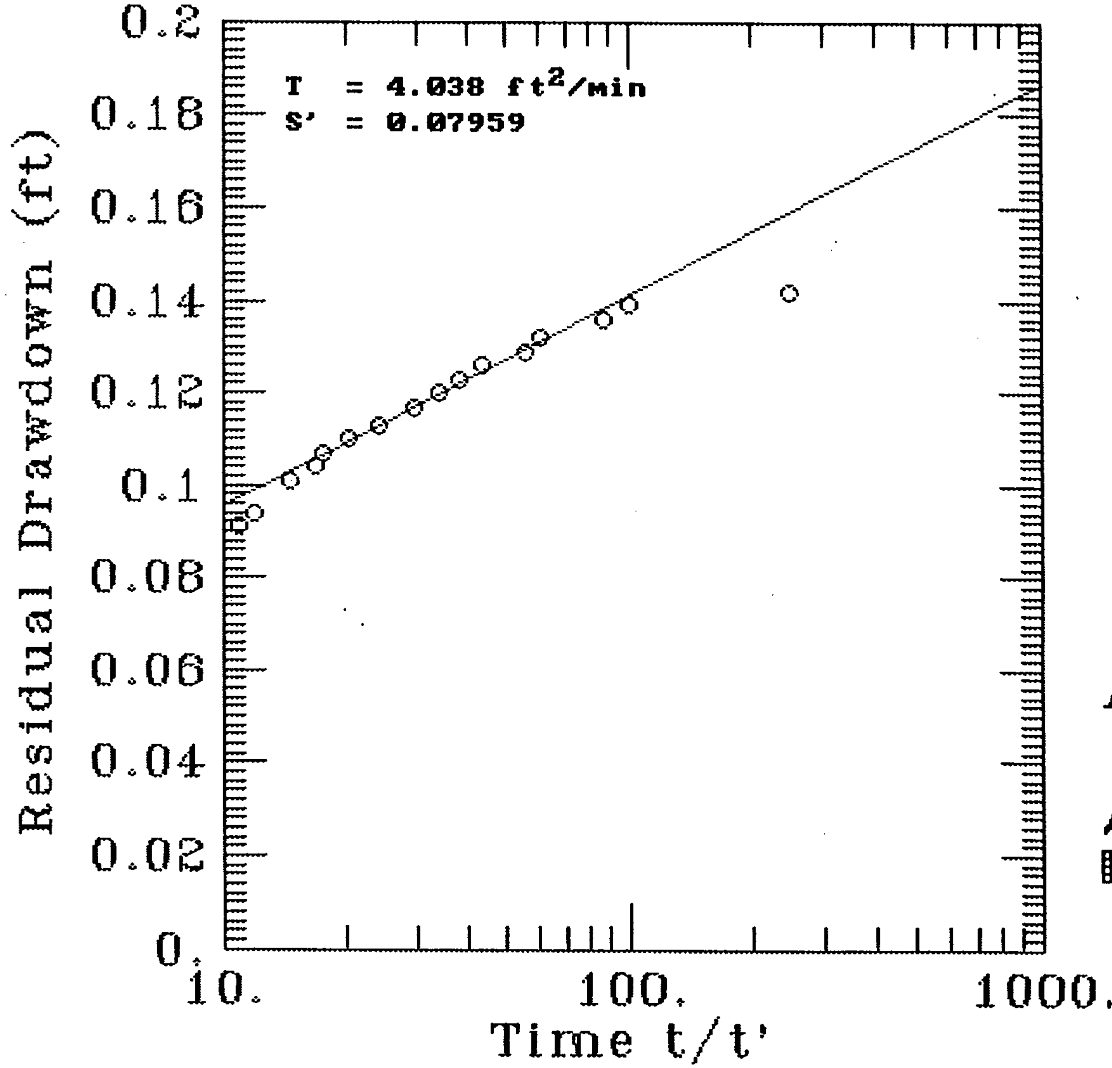
FRESNO ANG P-2 RECOVERY TEST



AQTESOLV

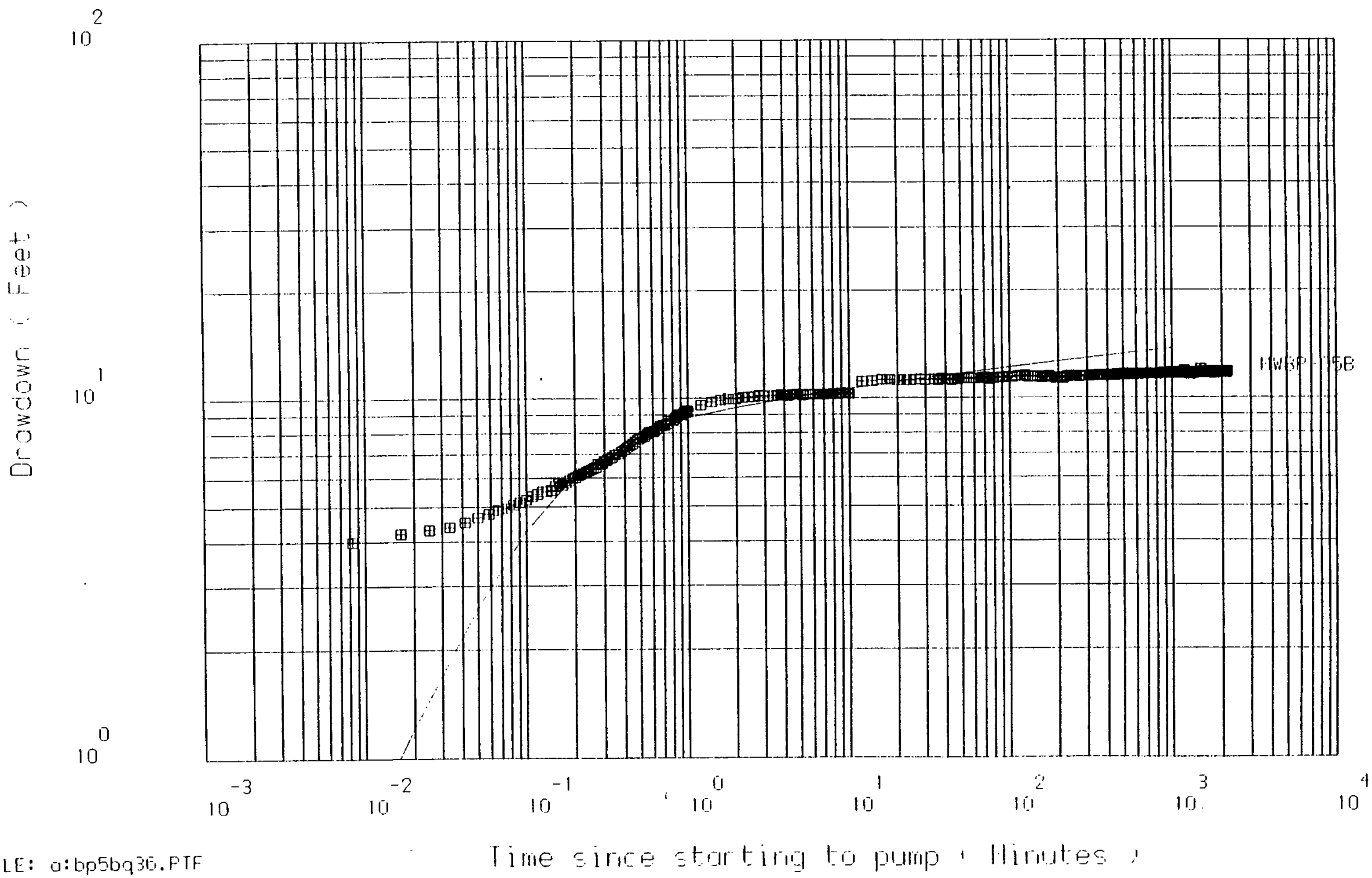
GERAGHTY & MILLER, INC.

Modeling Group

[PUMPING TEST LOG-LOG ANALYSIS : Papadopulos & Cooper TYPE CURVE 0.0001]

Pumping well	: MWBP-05B		
Pumping rate	Q =	16.00 USG/Min	
Radius of casing	rc =	0.1600 FT	
Radius of well bore	rw =	0.5000 FT	
	Alfa =	0.00010	

Transmissivity	T =	2684.574 USGPD/FT	
Storativity	S =	0.00000397	
Stor. [Alfa*rc^2/rw^2]	S2 =	0.00001024	
MATCH POINT :			
1/uw	=	1.004e+06	1.00
F(uw,Alfa)	=	1.4641000	1.00
Time	=	1.00	0.0000010 Min
Drawdown	=	1.00	0.6830135 FT

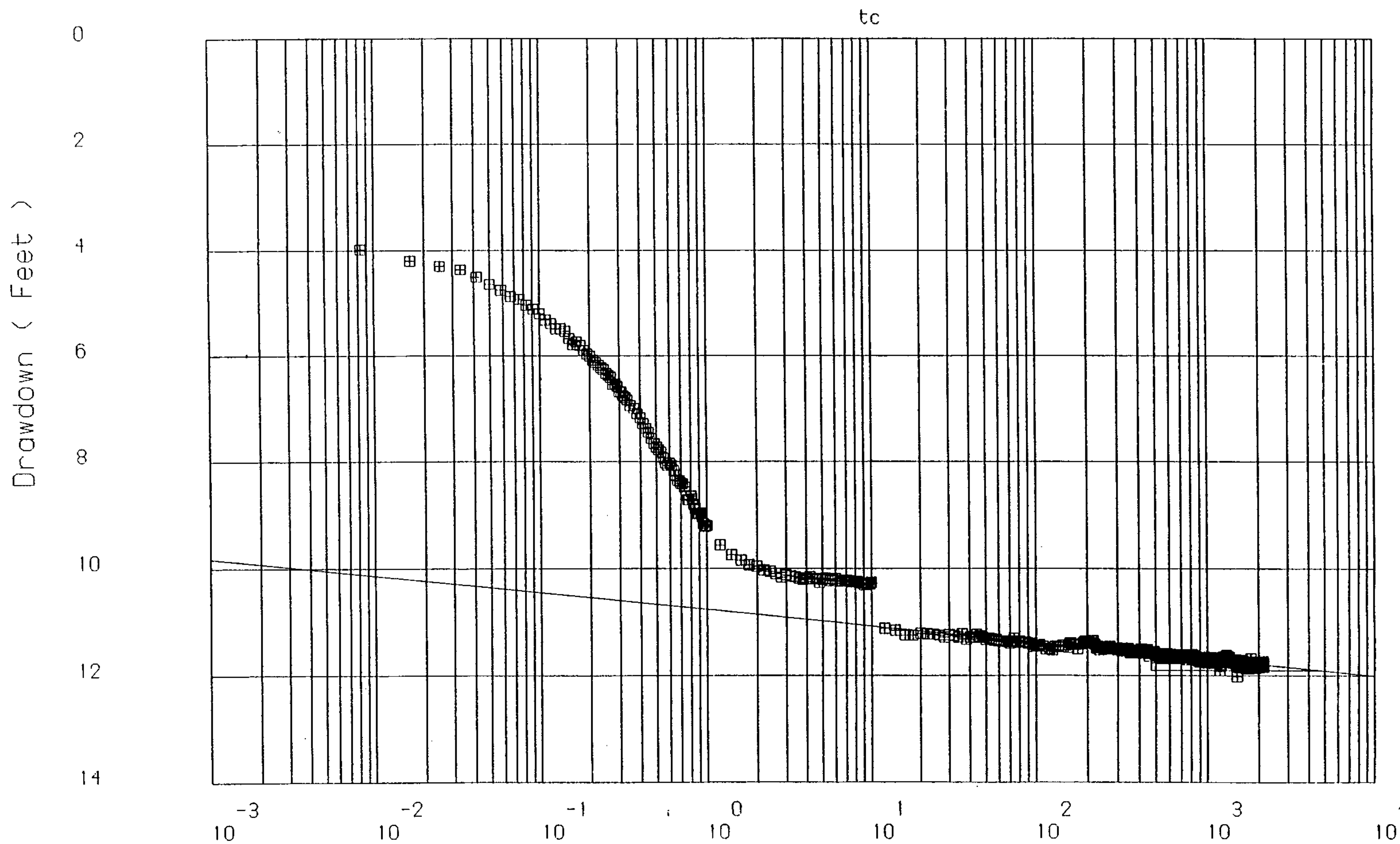


FILE: a:bp5bq36.PTF

[PUMPING TEST SEMI-LOG ANALYSIS : JACOB METHOD]

Pumping well : MWBP-05B
Pumping rate Q = 16.00 USG/Min

t0	=	2.74189148e-35 Min
ds	=	0.31136824 FT
T	=	13543.372 USGPD/FT
rc	=	0.5000 FT
rp	=	0.1600 FT
tc	=	8.94725469 Min



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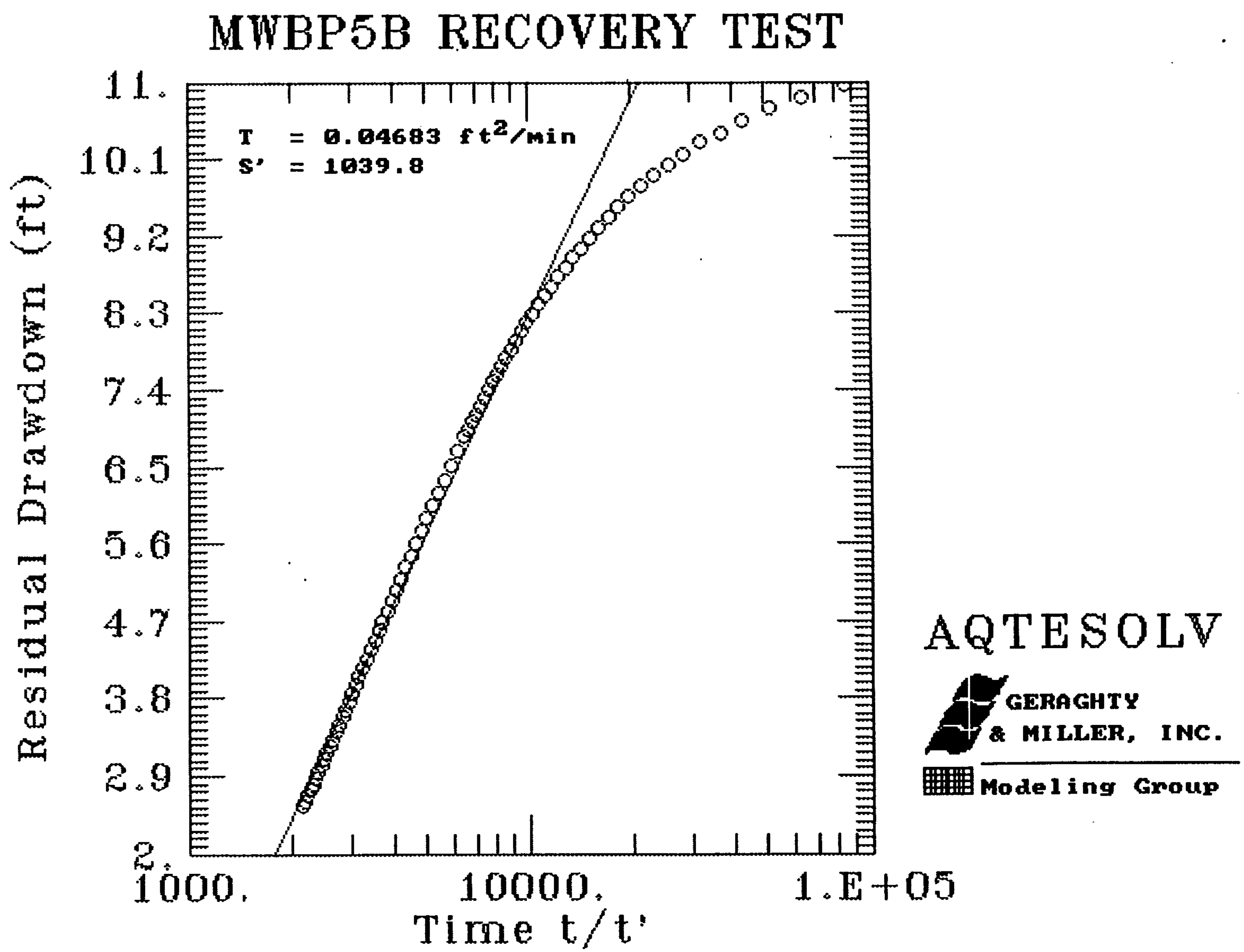
MWBP5B RECOVERY TEST
T = 0.04683 ft²/min
S' = 1039.8
Residual Drawdown (ft)
11.
10.1
9.2
8.3
7.4
6.5
5.6
4.7
3.8
2.9
2.
1000.
10000.
1.E+05
Time t/t'
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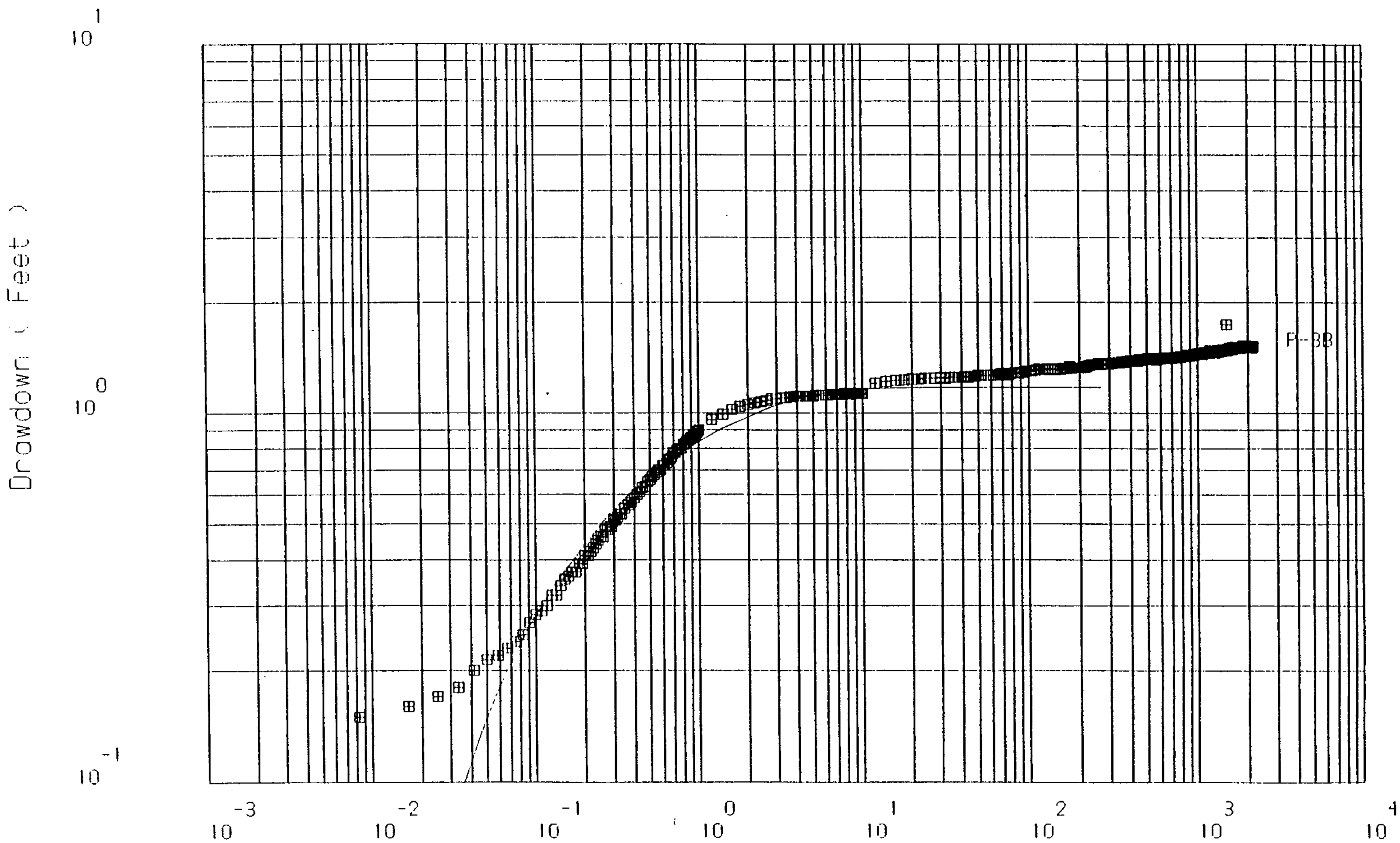
[PUMPING TEST LOG-LOG ANALYSIS : Jacob & Hantush TYPE CURVE 0.15]

Observation well	: P-3B		Transmissivity	T =	6330.084 USGPD/FT	
Distance	r =	20.00 FT	Storativity	S =	0.00015711	
Pumping well	: MWBP-05B		Vert. conductivity	K' =	2.84853802 USGPD/FT^2	
Pumping rate	Q =	16.00 USG/Min	MATCH POINT :			
Leaky bed thickness	b' =	8.0000 FT	1/u =	37.40	1.00	
	r/B =	0.15000	W(u,r/B) =	3.4522712	1.00	
			Time =	1.00	0.0267349 Min	
			Drawdown =	1.00	0.2896644 FT	



FILE: a:bp5bq36.PTF

[PUMPING TEST LOG-LOG ANALYSIS : Walton TYPE CURVE 0.1]

Observation well : P-3B

Distance r = 20.00 FT

Pumping well : MWBP-05B

Pumping rate Q = 16.00 USG/Min

Leaky bed thickness b' = 8.0000 FT

r/B = 0.10000

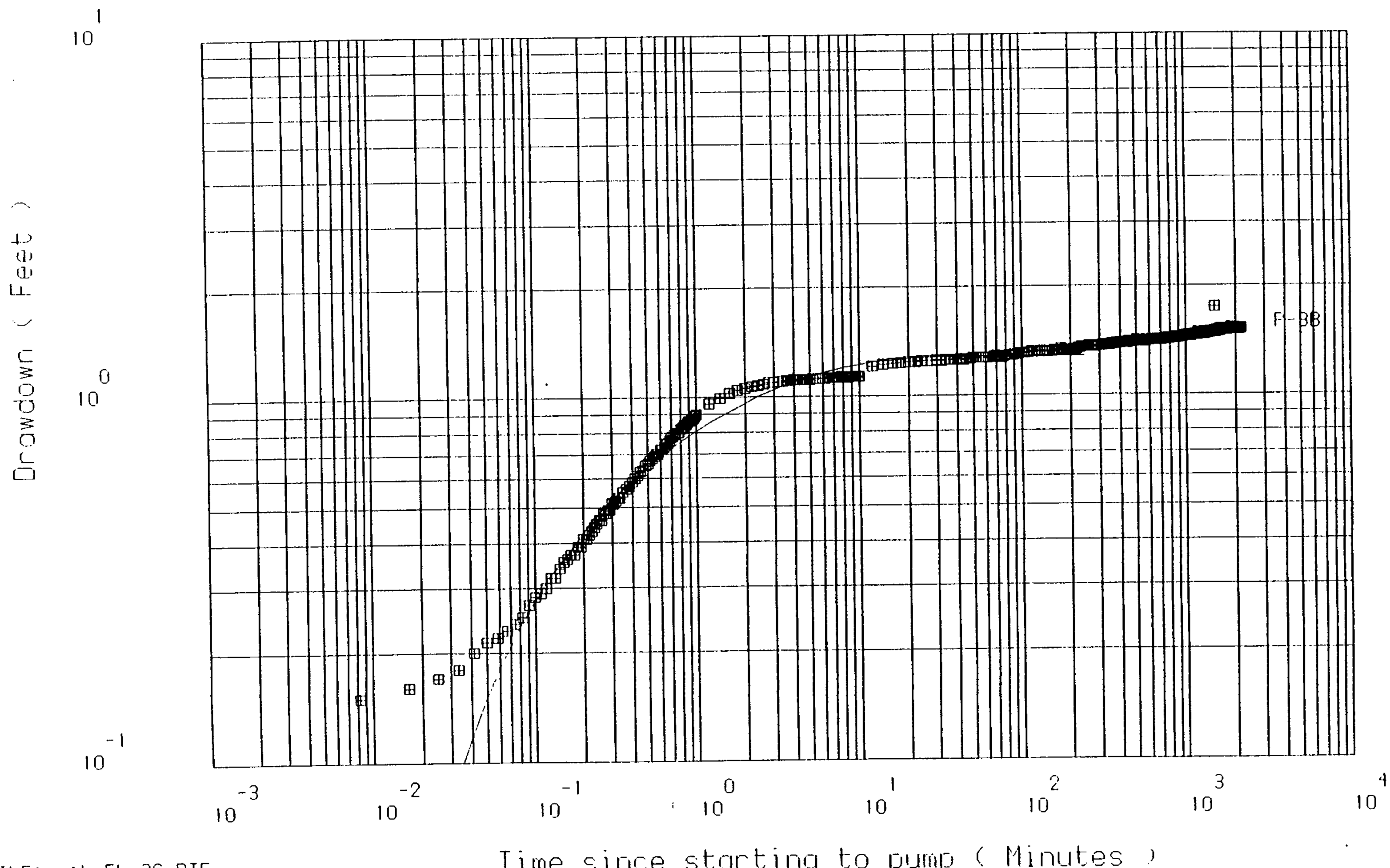
Transmissivity T = 6963.093 USGPD/FT

Storativity S = 0.00015711

Vert. conductivity K' = 1.39261859 USGPD/FT^2

MATCH POINT :

1/u =	41.14	1.00
W(u,r/B) =	3.7974983	1.00
Time =	1.00	0.0243044 Min
Drawdown =	1.00	0.2633313 FT



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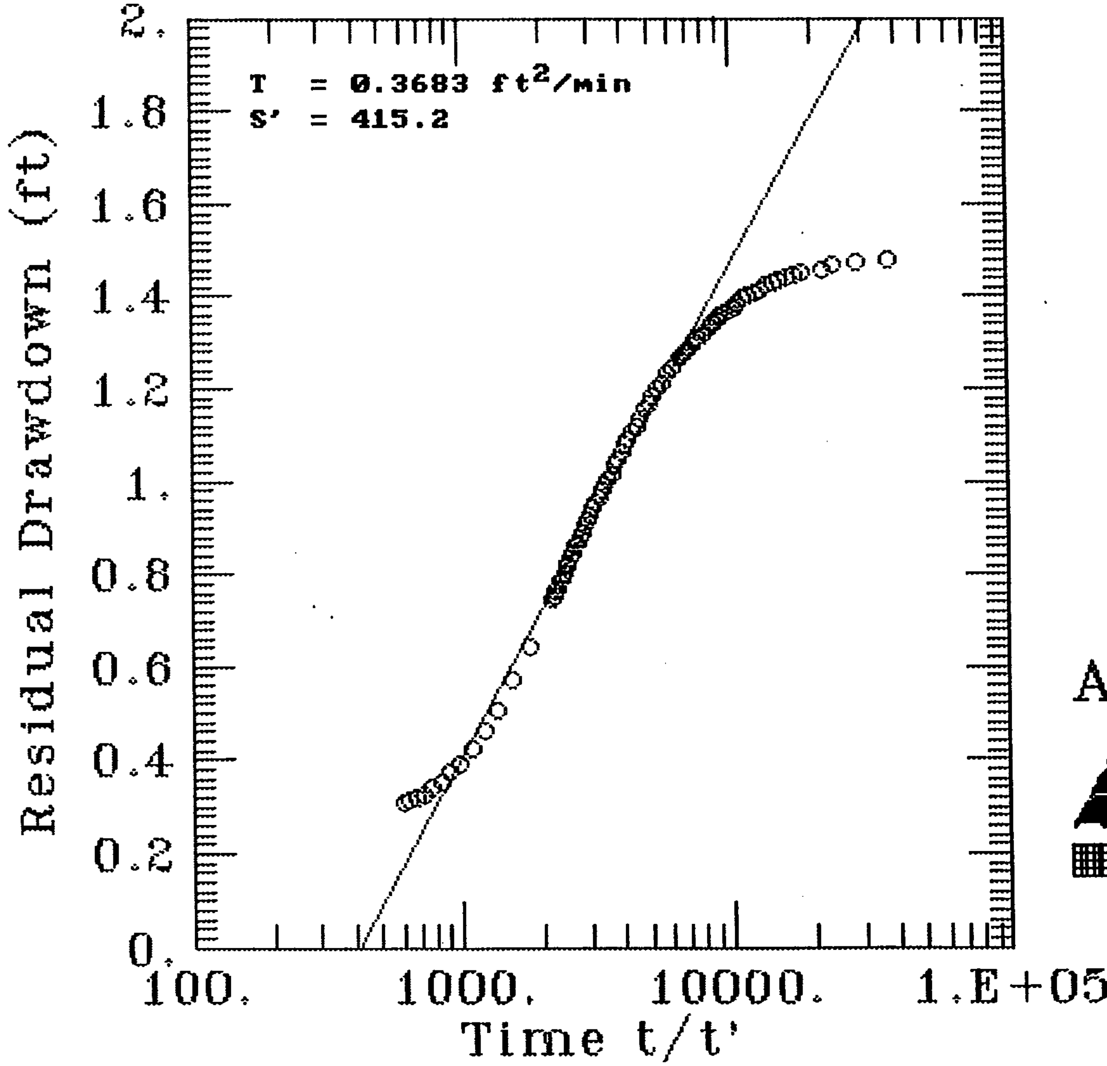
FRESNO ANG P-3B RECOVERY TEST



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[PUMPING TEST SEMI-LOG ANALYSIS : JACOB METHOD]

Observation well : P-5R

Distance r

Pumping well : MWRP 04R

Pumping rate Q

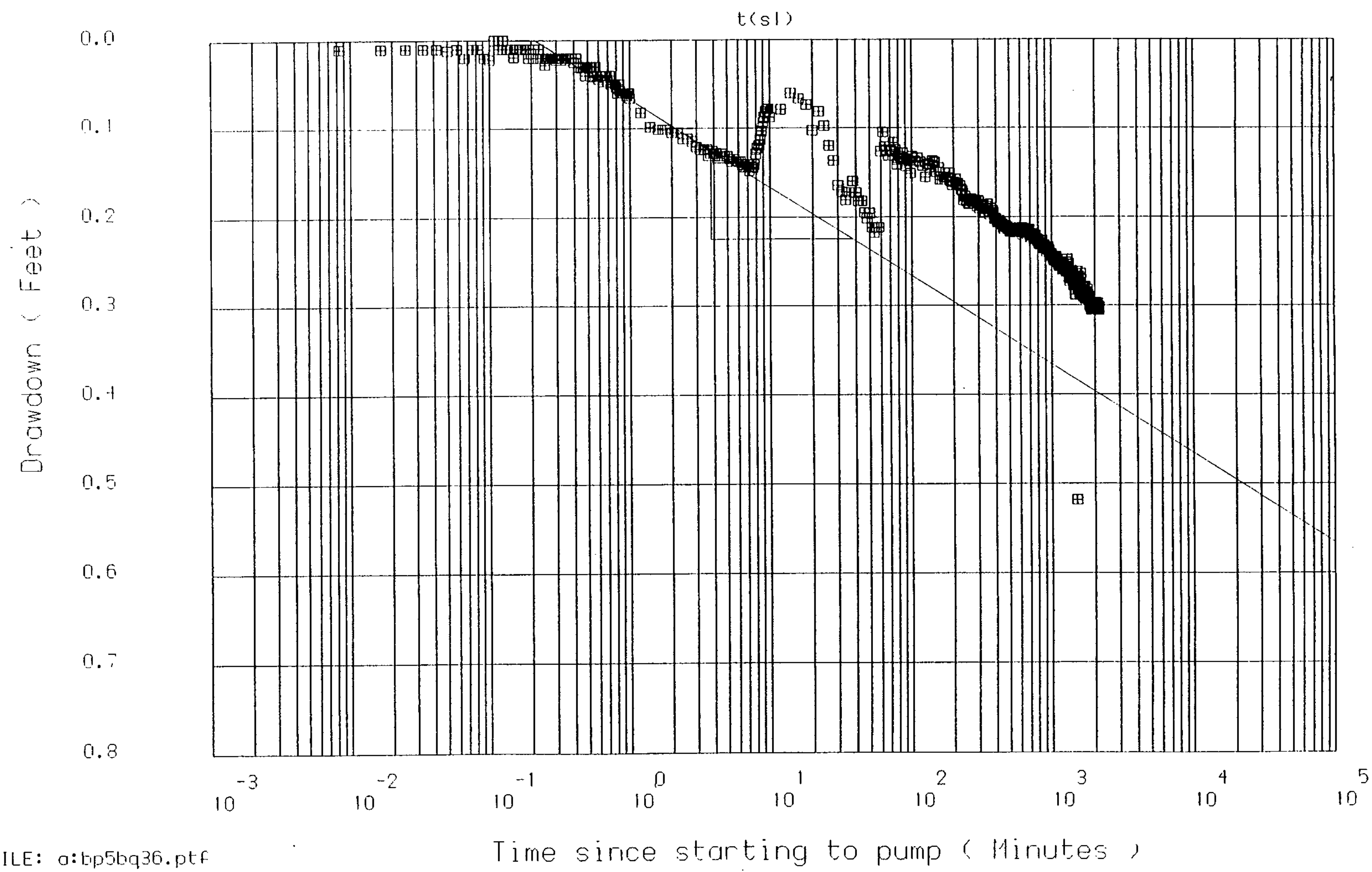
t0 = 0.21328578 Min

Δs = 0.09973444 FT

T = 42282.044 USGPD/FT

S = 0.0001916930

t(sl) = 5.99866267 Min



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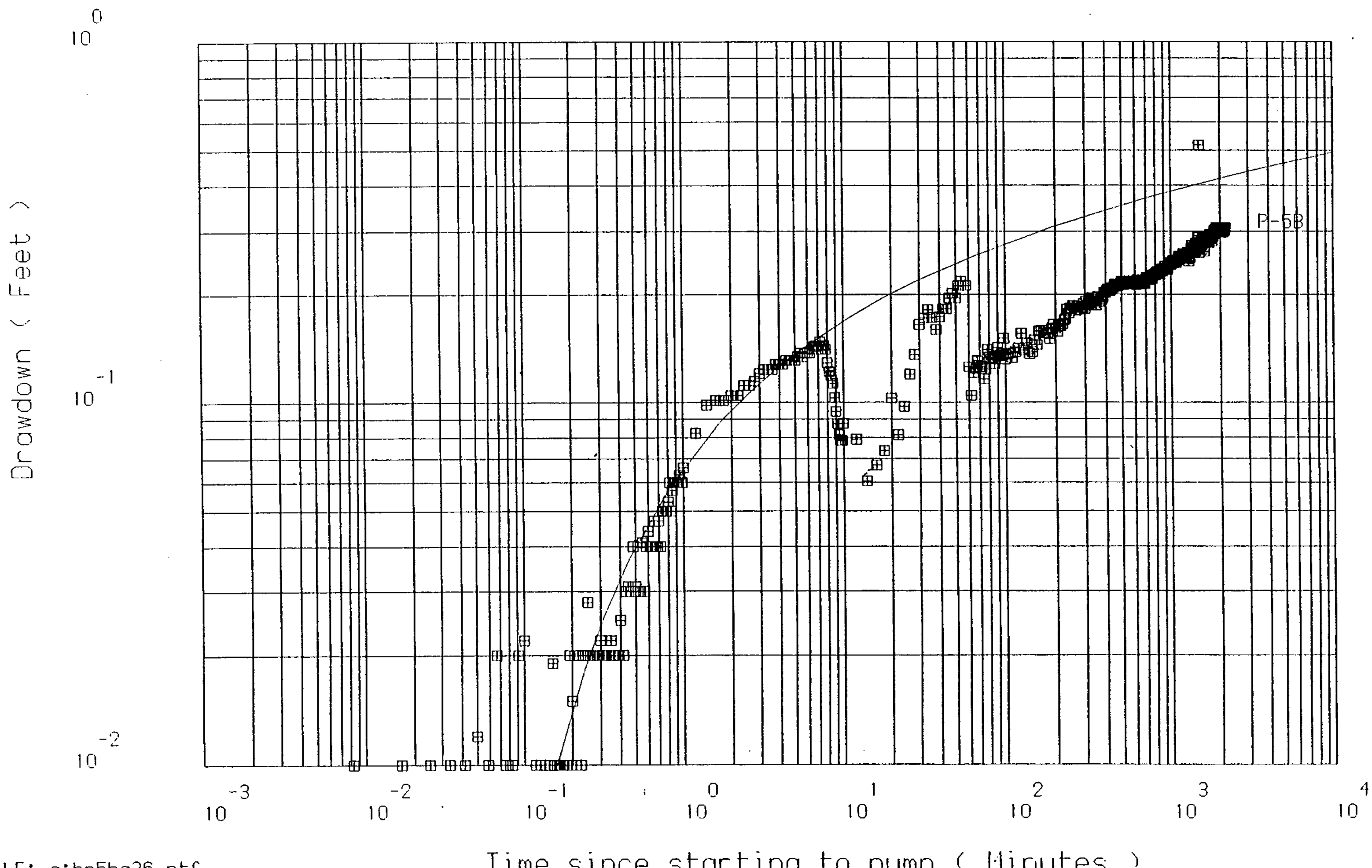
[PUMPING TEST LOG-LOG ANALYSIS : Rtheis TYPE CURVE Confined]

Observation well	: P-5B	
Distance	r =	99.00 FT
Pumping well	: MWBP-05B	
Pumping rate	Q =	16.00 USG/Min
Aquifer thickness	b =	8.0000 FT

Transmissivity	T =	38714.221 USGPD/FT	
Storativity	S =	0.00023983	
Hydr. conductivity	K =	4839.278 USGPD/FT^2	
MATCH POINT :			
1/u	=	6.1159090	1.00
W(u)	=	21.11	1.00
Time	=	1.00	0.1635080 Min
Drawdown	=	1.00	0.0473624 FT



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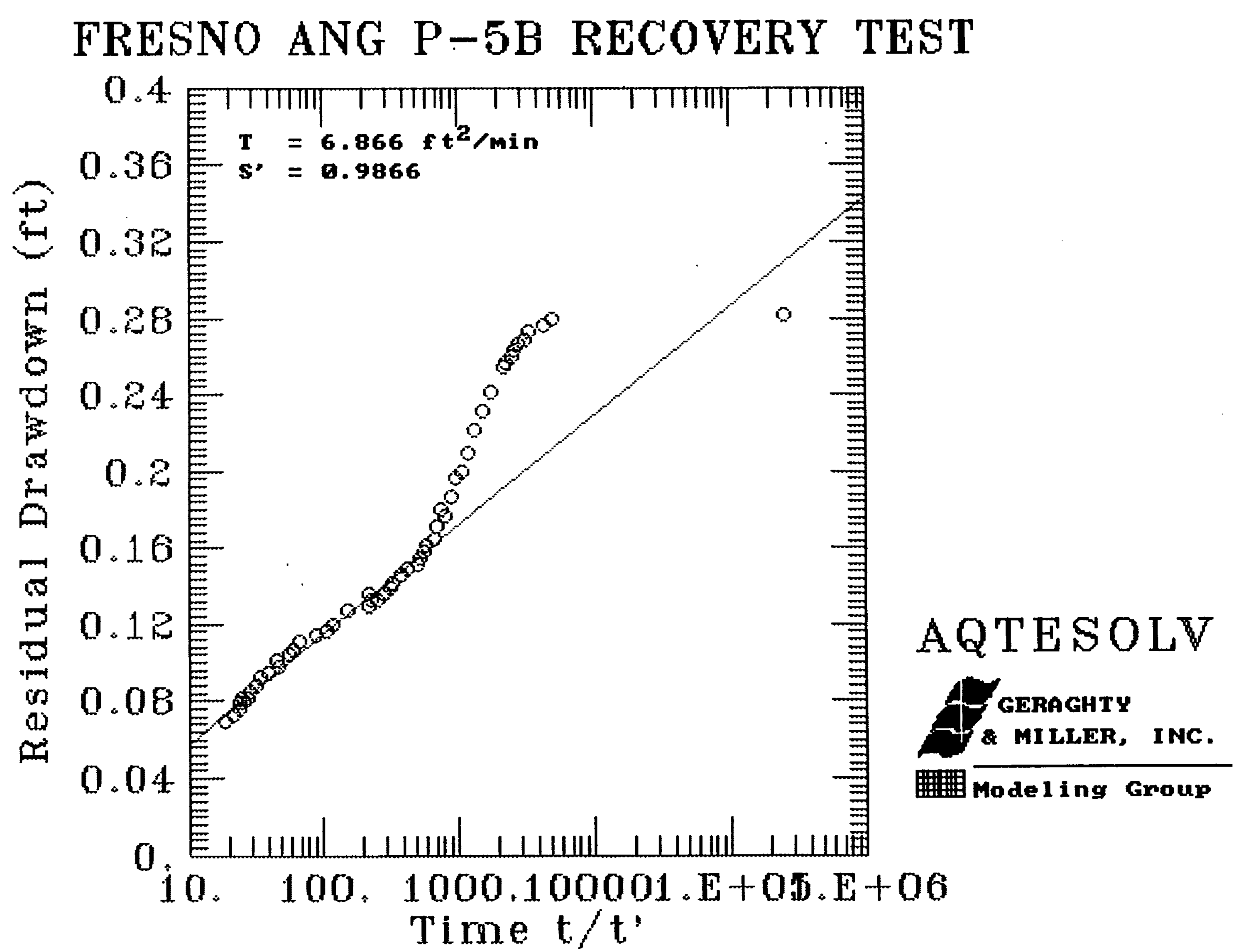

FRESNO ANG P-5B RECOVERY TEST
T = 6.866 ft²/min
S' = 0.9866
Residual Drawdown (ft)
0.4
0.36
0.32
0.28
0.24
0.2
0.16
0.12
0.08
0.04
0.
10.
100.
1000.
10000
1.E+05
1.E+06
Time t/t'
AQTESOLV
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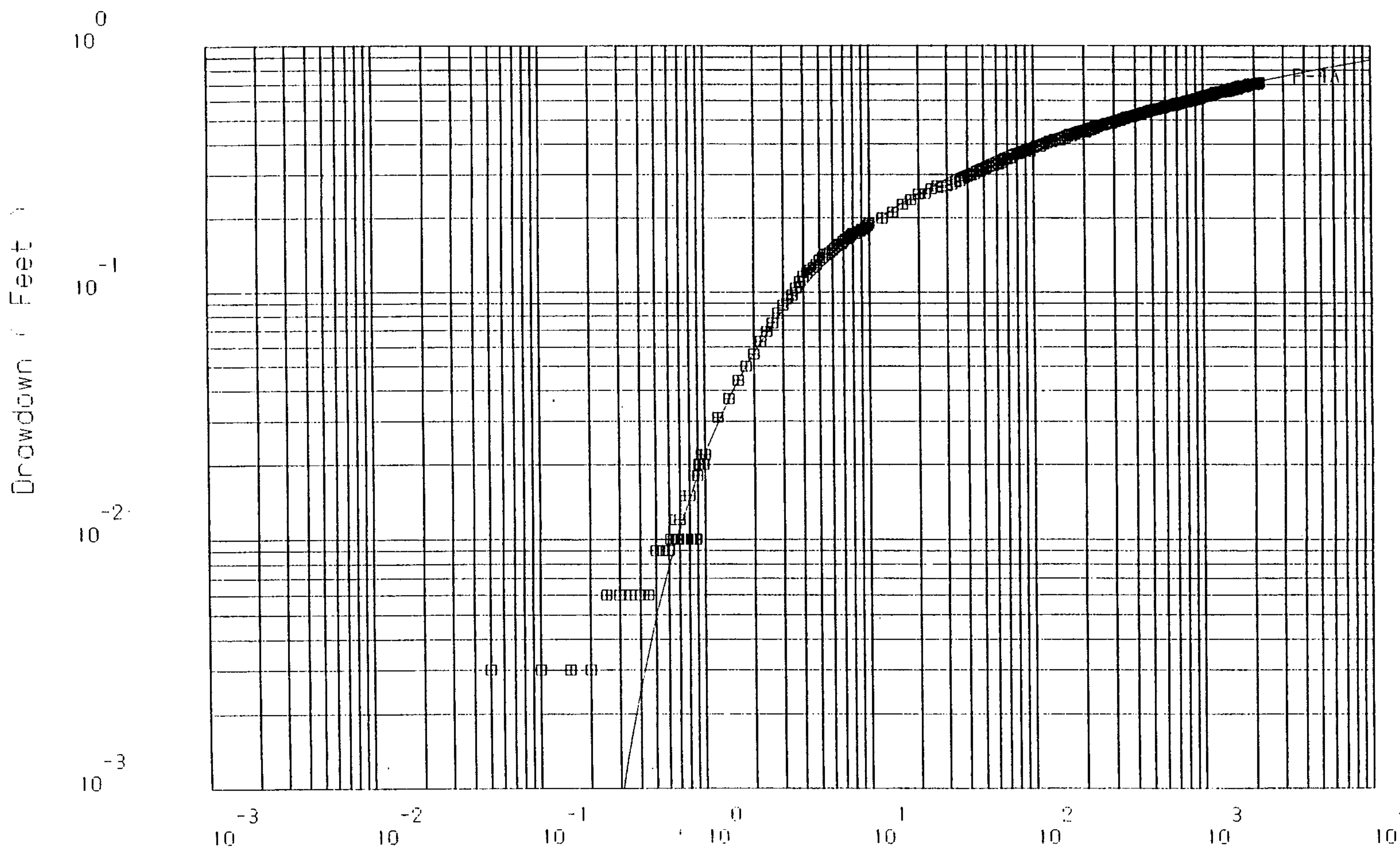
Modeling Group

[PUMPING TEST LOG-LOG ANALYSIS : Rtheis TYPE CURVE Confined]

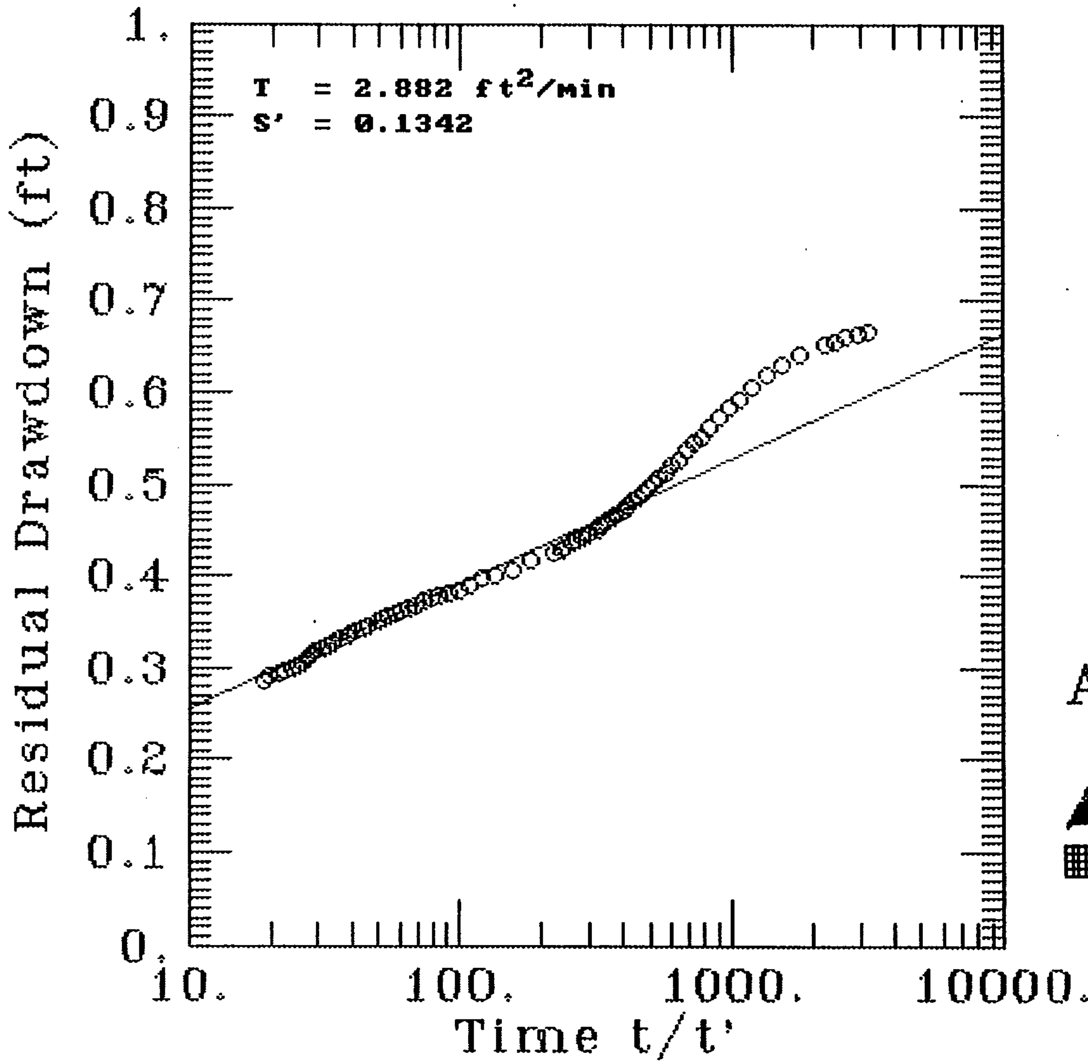
Observation well	: P-4A		
Distance	r =	40.00 FT	
Pumping well	: MWBP-05B		
Pumping rate	Q =	16.00 USG/Min	
Aquifer thickness	b =	8.0000 FT	

Transmissivity	T =	18060.470 USGPD/FT	
Storativity	S =	0.00419153	
Hydr. conductivity	K =	2257.559 USGPD/FT^2	
MATCH POINT :			
1/u	=	1.0000000	1.00
W(u)	=	9.8497327	1.00
Time	=	1.00	1.0000000 Min
Drawdown	=	1.00	0.1015256 FT



FILE: a:bp5bq36.PTF

FRESNO ANG P-4A RECOVERY TEST



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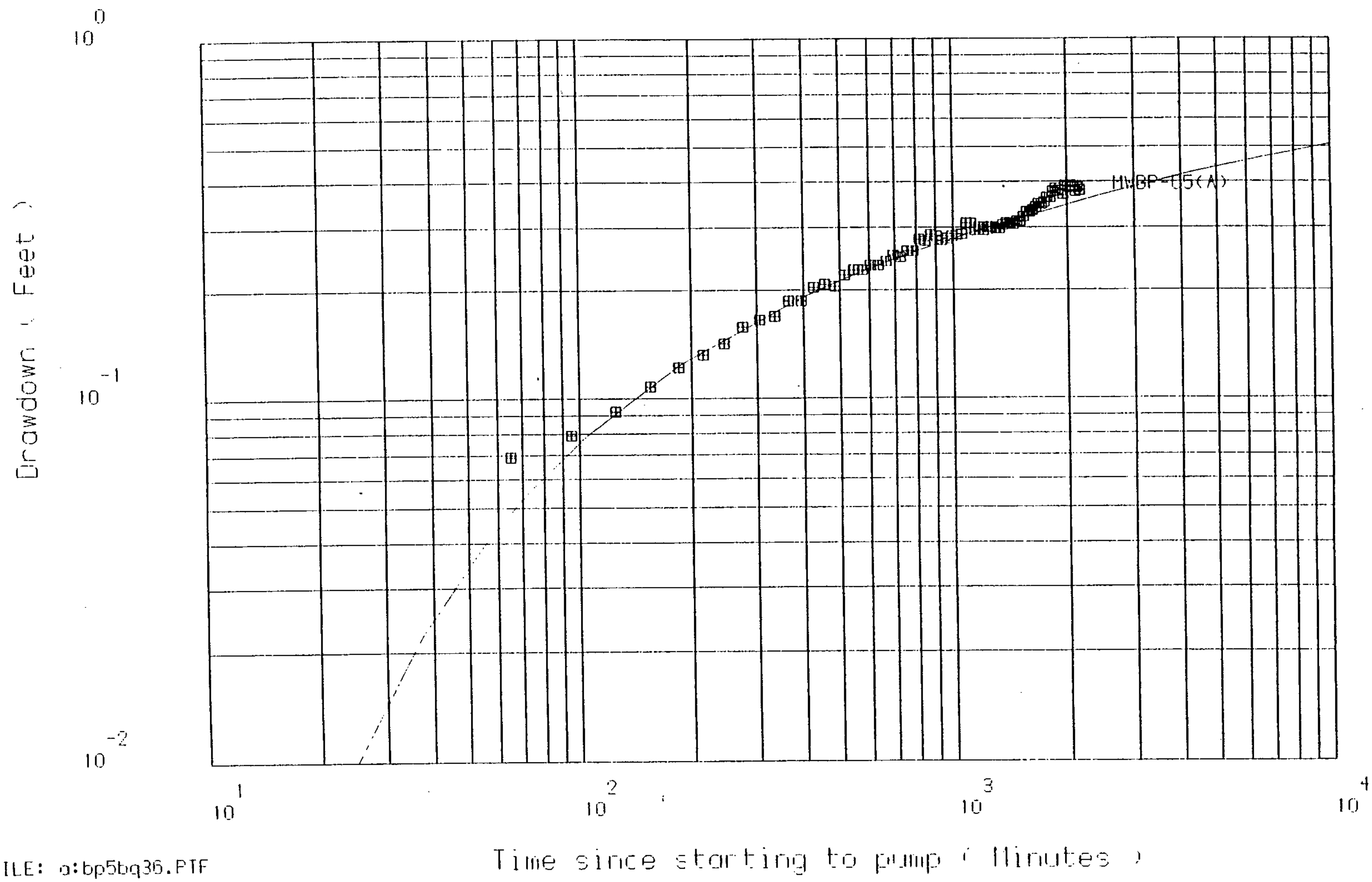
[PUMPING TEST LOG-LOG ANALYSIS : Rtheis TYPE CURVE Confined]

Observation well : MWBP-05(A)
Distance r = 102.00 FT
Pumping well : MWBP-05B
Pumping rate Q = 16.00 USG/Min
Aquifer thickness b = 8.0000 FT

Transmissivity T = 18060.470 USGPD/FT
Storativity S = 0.02411095
Hydr. conductivity K = 2257.559 USGPD/FT^2
MATCH POINT :

1/u	=	0.0267349	1.00
W(u)	=	9.8497327	1.00
Time	=	1.00	37.40 Min
Drawdown	=	1.00	0.1015256 FT



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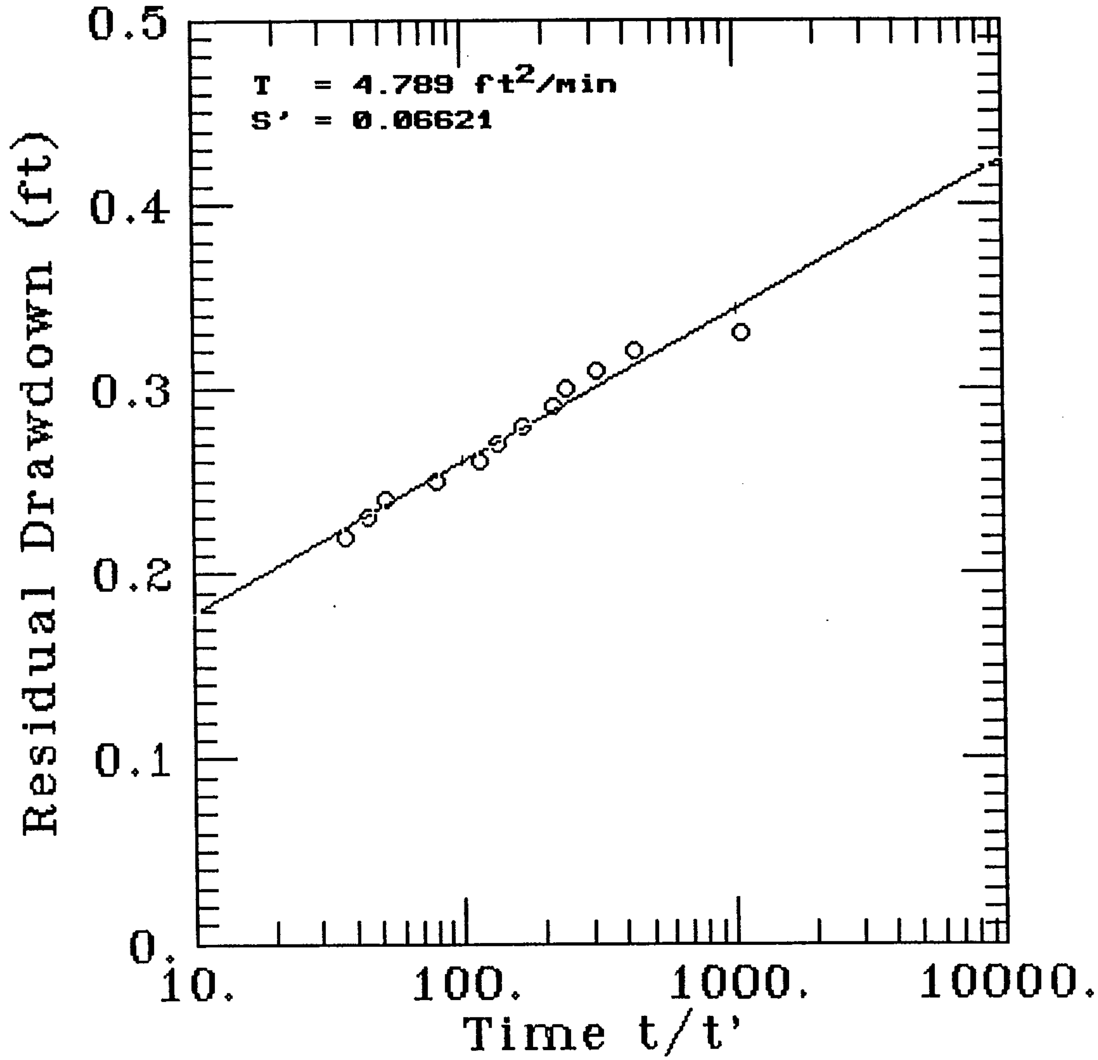
FRESNO ANG MWBP--05 RECOVERY TEST



3.2 In accordance with Theis (1935) recovery method, upon completion of a pumping test, recovery occurs at a constant rate with the residual drawdown given by:

$$s' = \frac{Q}{4\pi T} W(u) - W(u') \tag{4}$$

where $u = \frac{r^2 S}{4Tt}$ and $u' = \frac{r^2 S'}{4Tt'}$

s' is the residual drawdown, Q is the rate of well recharge which is equal to the rate of well discharge, S' is the dimensionless storativity of the aquifer during recovery, and t' is the time since the cessation of pumping.

For r small and t' large, equation (4) can be written as

$$s = \frac{2.30Q}{4\pi T} \log \frac{t}{t'} \tag{5}$$

A plot of residual drawdown s' versus t/t' on semi-log paper (t/t' on logarithmic scale) yields a straight line. The slope of the line equals $\frac{2.30Q}{4\pi T}$ so that for $\Delta s'$, the residual drawdown per log cycle of t/t', the transmissivity becomes :

$$T = \frac{2.30Q}{4\pi \Delta s'}$$

where $\Delta s'$ is the residual drawdown difference per log cycle of t/t'.

$$T = \frac{2.30 \ x \ 7.5 \ gpm \ x \ 0.134 \ x \ \log(50 \ ft \ /15 \ ft)}{2\pi(0.853 \ ft \ - \ 0.193 \ ft)}$$

where 0.134 = conversion factor gpm to ft^3/min

T = 0.292 ft^2/min

(ii) At t = 450 minutes $s'_1 = 0.786$ ft $r_1 = 15$ ft
$s'_2 = 0.137$ ft $r_2 = 50$ ft

T = 0.296 ft^2/min

2. A. Pumping MWBP-05B at 16 gpm with observation wells P-4A and MWBP-05 (Shallow water-bearing Zone)

(i) At t = 2160 minutes $s'_1 = 0.707$ ft $r_1 = 40$ ft
$s'_2 = 0.379$ ft $r_2 = 102$ ft

T = 0.981 ft^2/min

(ii) At t = 1205 $s'_1 = 0.65$ ft $r_1 = 40$ ft
$s'_2 = 0.294$ ft $r_2 = 102$ ft

T = 0.902 ft^2/min

B. Pumping MWBP-05B at 16 gpm with wells P-5B and P-3B as the observation points (deep water bearing zone).

At t = 2160 minutes $s'_1 = 0.306$ ft $r_1 = 99$ ft
$s'_2 = 1.519$ ft $r_2 = 20$ ft

T = 0.449 ft^2/min

INTERNATIONAL
TECHNOLOGY
CORPORATION

By AM Date 9/14/95 Subject Transmissivity Calculations Sheet No. 1 of 2

Chkd. By SL Date 9/18/95 FRESNO ANG Proj. No. 409724

The Thiem-Dupuit method was used to calculate transmissivity of geologic materials in the shallow water-bearing zone and the deep water-bearing zone at the Fresno ANG, Fresno, California. The Thiem-Dupuit method is based on the equation :

$$Q=2\pi rK\frac{dh}{dr}$$

after integration between r_1 and r_2 with ($r_2 > r_1$)

$$Q=\frac{\pi K(h_2^2-h_1^2)}{\ln(\frac{r_2}{r_1})}$$

since h=D -s

$$Q=\frac{2\pi KD(s_1-s_2)}{\ln(\frac{r_2}{r_1})}$$

$$T = KD$$

$$=\frac{2\pi KD(s_1-s_2)}{2.30\log(\frac{r_2}{r_1})}$$

$$T = \frac{Q}{2\pi(s_1-s_2)}\ln(\frac{r_1}{r_2})$$

where s' is the corrected drawdown for late time data and $s' = s-(s^2/2D)$

1. Pumping MWBP-12 at 7.5 gpm with observation wells P-1 and P-2:

(i) At t = 1200 minutes $s'_1 = 0.858$ ft $r_1 = 15$ ft
$s'_2 = 0.193$ ft $r_2 = 50$ ft

INTERNATIONAL TECHNOLOGY CORPORATION

By S. Logan Date 10/24/95 Subject P-3B Pump Test Analysis, Hantush Modification to the Theis Method, Fresno ANG Sheet No. 1 of 4

Chkd. By BLP Date 11/2/95 Proj. No. 409724

1.0 Objective

To determine the effects of partial penetration on aquifer test results from aquifer test data obtained at the Fresno ANG Base. Hantush's (1961a, 1961b) modification tothe Theis method for partially penetrating wells was chosen as being the most applicable among several methods for P-3B.

2.0 Background

A constant rate discharge test was conducted in monitoring well MWBP-05B at the Fresno ANG Base for a period of 36 hours. The discharge rate was maintained at a constant 16 gallons per minute (2.139 ft^3/min) for the test duration. The pumping well partially penetrates a semiconfined aquifer which is about 45 feet thick. Drawdown measurements at four monitoring points were collected during the test. The only observation point in which supposed partial penetration effects were noted was in piezometer P-3B. This piezometer is located 20 feet from the pumping well and is screened over the exact screened interval as the pumping well.

Figure 1 shows the configuration of the pump test monitoring network and well geometries in relation to the hydrogeologic setting.

3.0 Method

The following discussion of the Hantush partial penetration method is taken from Kruseman and de Ridder (1991). This method is not applicable for the pumping well.

For a relatively short pumping time, the drawdown in a piezometer at a distance, r, from a partially penetrating well is, according to Hantush (1961a, 1961b):

$$s = \frac{Q}{8\pi K(b-d)} E\left(u, \frac{b}{r}, \frac{d}{r}, \frac{a}{r}\right) \qquad (1)$$

where

$$E\left(u, \frac{b}{r}, \frac{d}{r}, \frac{a}{r}\right) = E(u) = M(u,B_1) - M(u,B_2) + M(u,B_3) - M(u,B_4) \qquad (2)$$

$$u = \frac{r^2 S_s}{4Kt} \qquad (3)$$

S_s = S/D = Specific storage
B_1 = (b+a)/r (for symbols b, d, and a, see Figure 1)
B_2 = (d+a)/r
B_3 = (b-a)/r
B_4 = (d-a)/r
Q = discharge rate
K = hydraulic conductivity
D = aquifer thickness
s = drawdown at time, t
r = radial distance from pumping well
t = time with drawdown, s

INTERNATIONAL TECHNOLOGY CORPORATION

By S. Logan Date 10/24/95 Subject P-3B Pump Test Analysis, Hantush Modification to the Theis Method, Fresno, ANG. Sheet No. 1A of 4

Chkd. By BLP Date 11/2/95 Proj. No. 409724

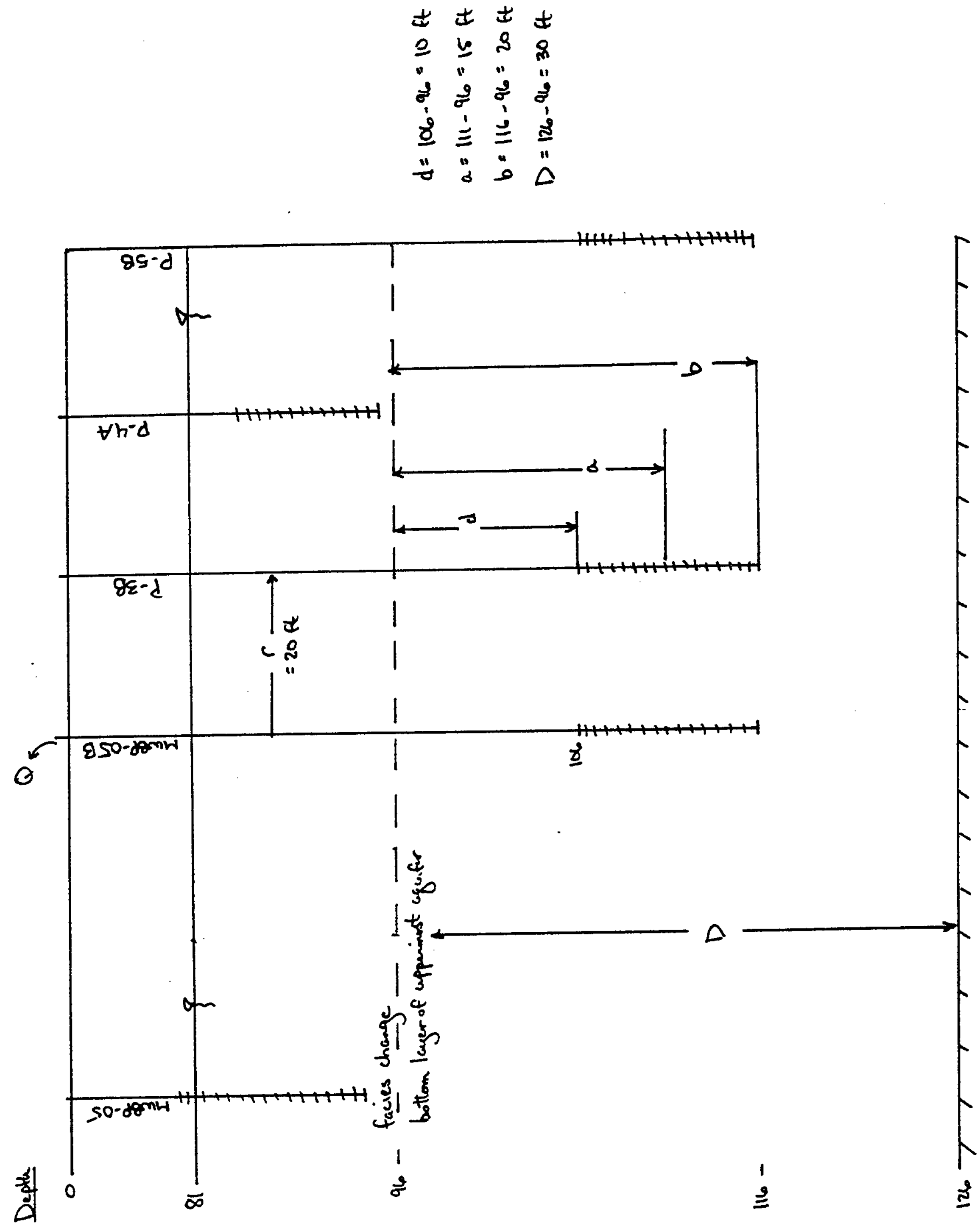


Figure 1
Well Geometries - Pump Test at MWBP-05B

Numerical values for M(u,B) are given in Kruseman and de Ridder (1991) and those which apply are included in Table 1 (see Section 5).

The following assumptions and conditions underly this method:

1) The aquifer is confined.
2) The aquifer has a seemingly infinite areal extent.
3) The aquifer is homogeneous, isotropic and of uniform thickness over the area influenced by the test.
4) Prior to pumping, the piezometric surface is nearly horizontal over the area that will be influenced by the test.
5) The aquifer is pumped at a constant discharge rate.
6) The well does not penetrate the entire thickness of the aquifer.
7) Flow to the well is in an unsteady state.
8) The time of pumping is relatively short: $t < [(2D-b-a)^2(S_s)]/20K$.

Discussion. Conditions 4) through 7) are met in this test. Given the type of alluvial aquifer system in which the wells are installed, Conditions 2) and 3) are not satisfied in their classic sense. As for condition 1), the aquifer has been assessed to be semiconfined, and portions of other tests react similar to confined aquifers. Applying a confined method is considered appropriate for the aquifer. Condition 8) will be assessed later in the calculation.

4.0 Procedure

- For one observation point, determine values for B_1, B_2, B_3 and B_4. Using these B values, find the values of $M(u,B_n)$ for different values of 1/u. Use equation (2) to calculate values for E(u) at various values for 1/u.
- Plot values of E(u) versus 1/u on log-log paper; this gives the type curve.
- At the same scale as the type curve, plot (corrected) drawdown versus time for the observation point.
- Match the data curve to the type curve. At relatively large values of time, the data should diverge from the type curve; this is to be expected because the type curve is based on the assumption that the pumping time is short.
- Select a match point "A" on the superimposed sheets and note values of s, t, E(u) and 1/u.
- Substitute the values for s and E(u) into equation (1) and calculate K.
- Substitute values of t, 1/u and K into equation (3) and calculate S_s.
- Data should be used from piezometers at a distance, $r < 2D$.

5.0 Application

This method was unable to be applied to the pumping well, MWBP-05B. Piezometer P-3B showed an effect from partial penetration and this method was used for it. Data from piezometer P-5B did not follow any classic response patterns and the Hantush method could not be applied to it. Responses in observation points P-4A and MWBP-05 followed that of a confined aquifer and did not show any effects of partial penetration or delayed yield; therefore, they were not analyzed by this method. Only the data from P-3B could be used

in this analysis.

Figure 1 shows the well geometry used in asigning values for b, d and a. These parameters were calculated not from the top of the water table, but from the contact between a coarse-grained and fine-grained material beneath the water table. This interface was used as the aquitard and is asserted to be the zone which is actually analyzed under this method. Table 1 provides the calculations for the various Bs and the function E(u). Values for M(u,B) are from Kruseman and de Ridder (1991).

Figure 2 shows the resulting type curve generated from 1/u and E(u) and Figure 3 shows the plot of drawdown data at P-3B at the same scale as Figure 2. A transparency for Figure 2 is also attached. The match point at E(u) = 1 and 1/u = 10 has values on Figure 3 of t = 0.58 minutes and s = 1.25 feet. Rearranging eq. (1) to solve for K with s = 1.25 ft, (b-d) = 10 ft (Table 1), and Q = 2.139 ft^3/min gives:

$$K = \frac{2.139\,ft^3/min}{8\pi(1.25\ ft)(10\ ft)} \times (1) = 6.81\times10^{-3}\ ft/min = 9.8\ ft/day$$

Given that the thickness (D) of the lower portion of the aquifer is 30 feet, the transmissivity, T, = KD = 9.8 x 30 = 294 ft^2/day.

Rearranging eq. (3) to solve for S_s with u = 0.1, t = 0.58 min and r = 20 ft, gives:

$$S_s = \frac{4(0.1)(6.81\times10^{-3}\ ft/min)(0.58\ min)}{(20\ ft)^2} = 3.95\times10^{-6}\ ft^{-1}$$

And the storativity, S = S_sD = 3.95x10^{-6}(30) = 1.18x10^{-4} (dimensionless).

Assessment. The piezometer, P-3B, is located 20 feet from the pumping well. This satisfies the condition of r < 2D (60 feet). The time of pumping which appears to be applicable from Section 3.0 is $t < \{(2D-b-a)^2(S_s)\}/20K$.

$(2D-b-a)^2$ = (60-20-15 feet)^2 = 625 ft^2. 625 ft^2 x 3.95x10^{-6} ft^{-1} = 2.47x10^{-3} ft.
Now K = 6.8x10^{-3} ft/min and 20K = 0.136 ft/min. 2.47x10^{-3} ft/ 0.136 ft/min = 0.018 min or 1.09 seconds. This seems unreasonably low for pumping time. The chosen time of 0.58 minutes is about 35 seconds, which seems short enough to allow for the calculations to be considered valid.

6.0 Conclusion

The data set for P-3B exhibits the effects of partial penetration. Applying the Hantush method for partial penetration gives the following aquifer properties:

K = 9.8 ft/day
T = 294 ft^2/day
S_s = 3.95x10^{-6} ft^{-1}
S = 1.18x10^{-4}.

TABLE 1
Calculation of Values for E(u) Based on Equation 2

Setup: r = 20 ft (see Fig 1) b = 20 ft, d = 10 ft, a = 15 ft

$B_1 = (b+a)/r = 35/20 = 1.75 = 1.8$

$B_2 = (d+a)/r = 25/20 = 1.25 = 1.2$

$B_3 = (b-a)/r = 5/20 = 0.25$

$B_4 = (d-a)/r = -5/20 = -0.25$ (not used in calculation)

1/u	M(u,B): $M(u,B_1)$=1.8	$M(u,B_2)$=1.2	$M(u,B_3)$=.25	E(u...)[a]	Values used for interpolation of M(u,B) = 0.25.: $M(u,B_3)$=.20	$M(u,B_3)$=.30
1.00E+06	2.6968	2.0292	0.4938	1.1614	0.3969	0.5907
5.00E+05	2.6951	2.0281	0.4936	1.1606	0.3967	0.5904
2.50E+05	2.6927	2.0265	0.4933	1.1595	0.3965	0.59
1.66E+05	2.6909	2.0253	0.4930	1.1586	0.3963	0.5897
1.25E+05	2.6894	2.0243	0.4928	1.1579	0.3961	0.5894
1.00E+05	2.688	2.0234	0.4926	1.1572	0.3959	0.5892
5.00E+04	2.6827	2.0198	0.4919	1.1548	0.3954	0.5883
2.50E+04	2.6752	2.0148	0.4908	1.1512	0.3945	0.5871
1.66E+04	2.6694	2.011	0.4900	1.1484	0.3939	0.5861
1.25E+04	2.6645	2.0077	0.4893	1.1461	0.3933	0.5853
1.00E+04	2.6603	2.0049	0.4888	1.1442	0.3929	0.5846
5.00E+03	2.6434	1.9936	0.4864	1.1362	0.391	0.5818
2.50E+03	2.6197	1.9778	0.4831	1.1250	0.3883	0.5778
1.66E+03	2.6014	1.9656	0.4806	1.1164	0.3863	0.5748
1.25E+03	2.586	1.9554	0.4784	1.1090	0.3846	0.5722
1.00E+03	2.5725	1.9463	0.4765	1.1027	0.3831	0.5699
5.00E+02	2.5195	1.9109	0.4692	1.0778	0.3772	0.5611
2.50E+02	2.4447	1.861	0.4588	1.0425	0.3689	0.5486
1.66E+02	2.3875	1.8228	0.4508	1.0155	0.3625	0.539
1.25E+02	2.3395	1.7907	0.4441	0.9929	0.3571	0.531
1.00E+02	2.2975	1.7625	0.4382	0.9732	0.3524	0.5239
5.00E+01	2.1342	1.6527	0.4151	0.8966	0.334	0.4962
2.50E+01	1.9103	1.5008	0.3831	0.7926	0.3083	0.4578
1.66E+01	1.7454	1.3877	0.3590	0.7167	0.289	0.4289
1.25E+01	1.612	1.2951	0.3391	0.6560	0.2731	0.405
10	1.4991	1.2159	0.34185	0.6251	0.2993	0.3844
5	1.1026	0.9297	0.25825	0.4312	0.2084	0.3081
2.5	0.676	0.6015	0.18075	0.2553	0.1462	0.2153
1.66	0.4471	0.4122	0.13245	0.1674	0.1074	0.1575
1.25	0.3084	0.2913	0.09925	0.1164	0.0806	0.1179
1	0.2186	0.2101	0.07545	0.0840	0.0614	0.0895
0.5		0.0485	0.0213		0.0175	0.0251
0.25			0.0021		0.00176	2.44E-03
0.166			0.0002295		0.000195	2.64E-04
0.125			2.625E-05		2.26E-05	2.99E-05

a - $E(u,b/r,d/r,a/r)=M(u,B_1)-M(u,B_2)+M(u,B_3)$

Figure 2: E(u) type curve for P-3B well geometry

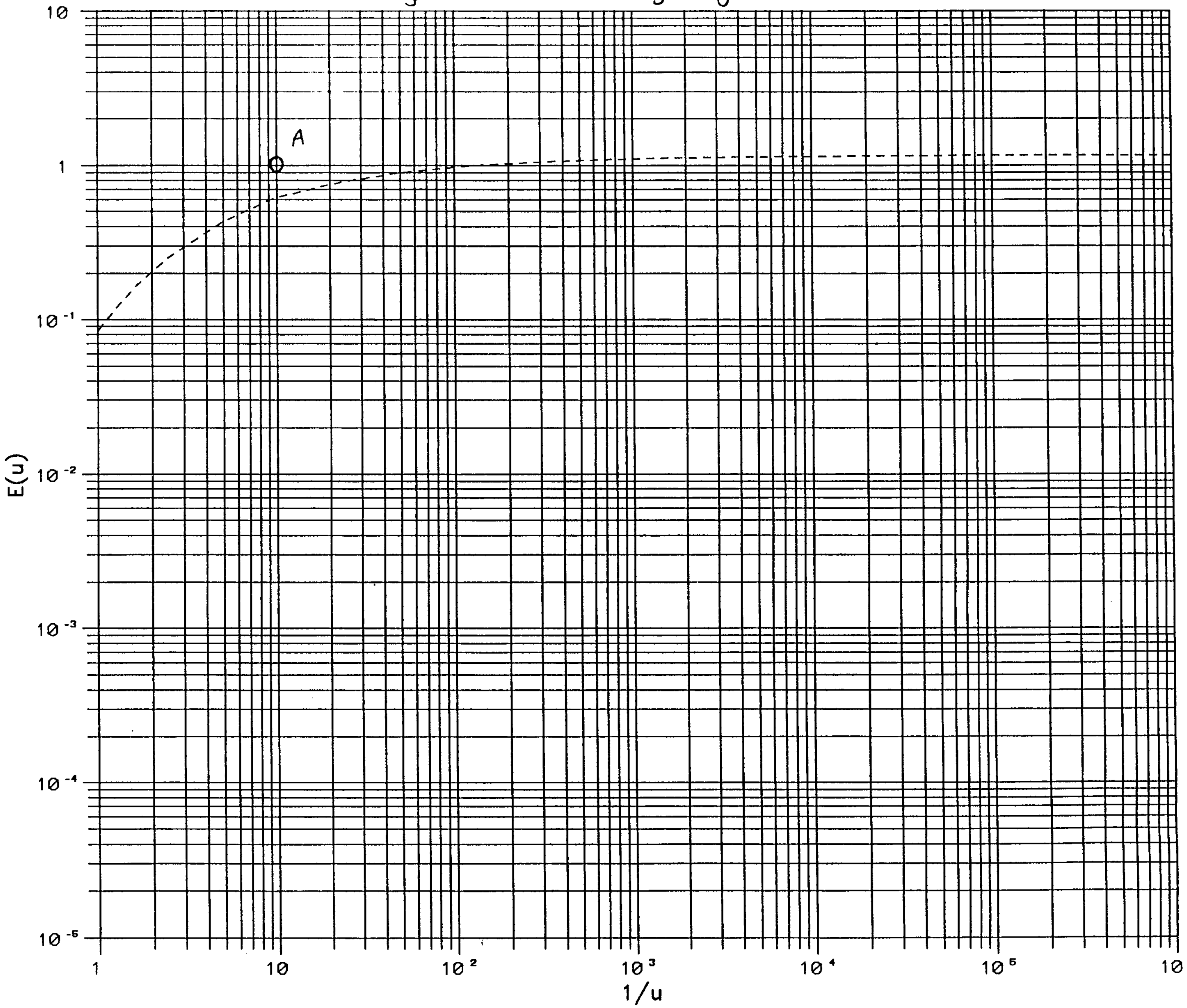


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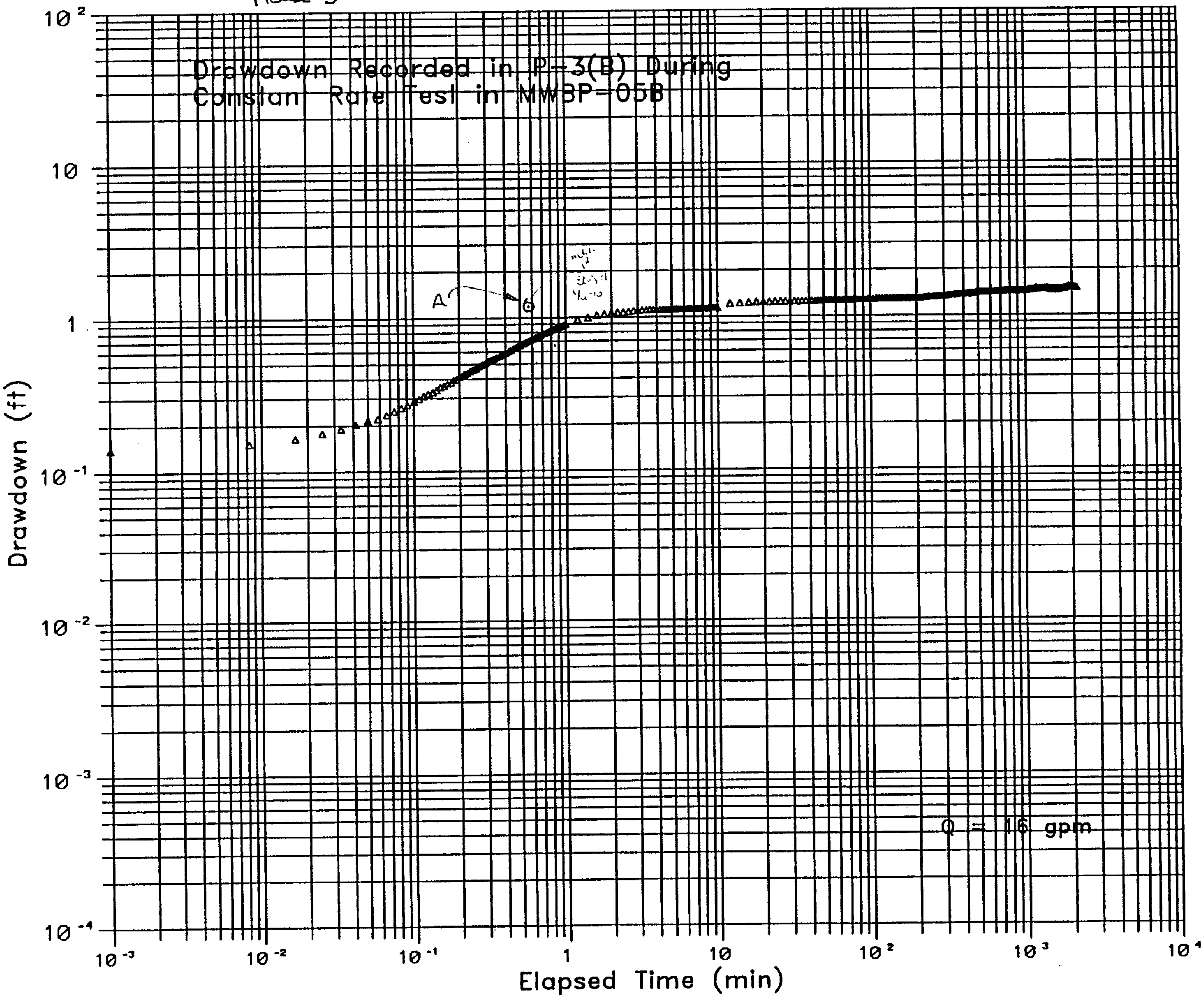
Figure 3



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INTERNATIONAL TECHNOLOGY CORPORATION

By S. Logan Date 10/24/95 Subject P-3B Pump Test Analysis, Hantush Modification to the Theis Method, Fresno ANG Sheet No. 4 of 4

Chkd. By BLK Date 11/2/95 Proj. No. 409724

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APPENDIX I

ANALYTICAL DATA SUMMARIES

Index to Appendix I

Table I-1

Analytical Parameter Target Compounds

Halogenated Volatile Organics - SW846, 8010

CAS No.	Target Compound
74-87-3	chloromethane
75-01-4	vinyl chloride
74-83-9	bromomethane
75-00-3	chloroethane
75-69-4	trichlorofluoromethane
75-35-4	1,1-dichloroethene
75-09-2	methylene chloride (dichloromethane)
156-60-5	trans-1,2-dichloroethene
75-34-3	1,1-dichloroethane
156-60-5	cis-1,2-dichloroethene
67-66-3	chloroform (trichloromethane)
71-55-6	1,1,1-trichloroethane
56-23-5	carbon tetrachloride
107-06-2	1,2-dichloroethane
79-01-6	trichloroethene
78-87-5	1,2-dichloropropane
75-27-4	bromodichloromethane
10061-01-5	trans-1,3-dichloropropene
10061-02-6	cis-1,3-dichloropropene
79-00-5	1,1,2-trichloroethane
127-18-4	tetrachloroethene
124-48-1	dibromochloromethane
108-90-7	chlorobenzene
75-25-2	bromoform
79-34-5	1,1,2,2-tetrachloroethane
541-73-1	1,3-dichlorobenzene
106-46-7	1,4-dichlorobenzene
95-50-1	1,2-dichlorobenzene
75-71-8	dichlorodifluoromethane

Aromatic Volatile Organics - SW846,8020

71-43-2	benzene
108-88-3	toluene
100-41-4	ethyl benzene
1330-20-7	xylenes (total)

Table I-1

Analytical Parameter Target Compounds

Semivolatile Organic Compounds - CLP

CAS No.	Target Compound
108-95-2	phenol
111-44-4	bis(2)-chloroethyl)ether
95-57-8	2-chlorophenol
541-73-1	1,3-dichlorobenzene
106-46-7	1,4-dichlorobenzene
100-51-6	benzyl alcohol
95-50-1	1,2-dichlorobenzene
95-48-7	2-methylphenol
108-60-1	bis(2-chloroisopropyl)ether
106-44-5	4-methylphenol
621-64-7	n-nitroso-di-n-propylamine
67-72-1	hexachloroethane
98-95-3	nitrobenzene
78-59-1	isophorone
88-75-5	2-nitrophenol
105-67-9	2,4-dimethylphenol
65-85-0	benzoic acid
111-91-1	bis(2-chloroethoxy)methane
120-83-2	2,4-dichlorophenol
120-82-1	1,2,4-trichlorobenzene
91-20-3	naphthalene
106-47-8	4-chloroaniline
87-68-3	hexachlorobutadiene
59-50-7	4-chloro-3-methylphenol
91-57-6	2-methylnaphthalene
77-47-4	hexachlorocyclopentadiene
88-06-2	2,4,6-trichlorophenol
95-95-4	2,4,5-trichlorophenol
91-58-7	2-chloronaphthalene
88-74-4	2-nitroaniline
131-11-3	dimethyl phthalate
208-96-8	acenaphthylene
606-20-2	2,6-dinitrotoluene
99-09-2	3-nitroaniline
83-32-9	acenaphthene
51-28-5	2,4-dinitrophenol
100-02-7	4-nitrophenol
132-64-9	dibenzofuran
121-14-2	2,4-dinitrotoluene
84-66-2	diethylphthalate
7005-72-3	4-chlorophenyl-phenylether
86-73-7	fluorene
100-01-6	4-nitroaniline
534-52-1	4,6-dinitro-2-methylphenol
86-30-6	n-nitrosodiphenylamine(1)
101-55-3	4-bromophenyl-phenylether
118-74-1	hexachlorobenzene
87-86-5	pentachlorophenol
85-01-8	phenanthrene
120-12-7	anthracene
84-74-2	di-n-butyl phthalate
206-44-0	fluoranthene
129-00-0	pyrene
85-68-7	butyl benzyl phthalate
91-94-1	3,3'-dichlorobenzidine
56-55-3	benzo(a)anthracene
218-01-9	chrysene
117-81-7	bis(2-ethylhexyl)phthalate
117-84-0	di-n-octyl phthalate
205-99-2	benzo(b)fluoranthene
207-08-9	benzo(k)fluoranthene
50-32-8	benzo(a)pyrene
193-39-5	indeno(1,2,3-cd)pyrene
53-70-3	dibenz(a,h)anthracene
191-24-2	benzo(g,h,i)perylene

Table I-1

Analytical Parameter Target Compounds

Pesticides/PCBs - CLP

CAS No.	Target Compound
319-84-6	alpha-BHC
319-85-7	beta-BHC
319-86-8	delta-BHC
58-89-9	gamma-BHC (lindane)
76-44-8	heptachlor
309-00-2	aldrin
1024-57-3	heptachlor epoxide
959-98-8	endosulfan I
60-57-1	dieldrin
72-55-9	4,4'-DDE
72-20-8	endrin
33213-65-9	endosulfan II
72-54-8	4,4'-DDD
1031-07-8	endosulfan sulfate
50-29-3	4,4'-DDT
72-43-5	methoxychlor
53494-70-5	endrin ketone
5103-71-9	alpha-chlordane
5103-74-2	gamma-chlordane
8001-35-2	toxaphene
12674-11-2	Aroclor-1016
11104-28-2	Aroclor-1221
11141-16-5	Aroclor-1232
53469-21-9	Aroclor-1242
12672-29-6	Aroclor-1248
11097-69-1	Aroclor-1254
11096-82-5	Aroclor-1260

Table I-1

Analytical Parameter Target Compounds

Metals - CCR List

CAS No.	Target Compound
7440-36-0	antimony
7440-38-2	arsenic
7440-39-3	barium
7440-41-7	beryllium
7440-43-9	cadmium
7440-47-3	chromium
7440-48-4	cobalt
7440-50-8	copper
7439-92-1	lead
7440-02-0	nickel
7782-49-2	selenium
7440-22-4	silver
7440-28-0	thallium
7440-62-2	vanadium
7440-66-6	zinc
7439-97-6	mercury
--	molybdenum

Metals - RCRA List

CAS No.	Target Compound
7440-39-3	barium
7440-38-2	arsenic
7440-43-9	cadmium
7440-47-3	chromium
7439-92-1	lead
7439-97-6	mercury
7782-49-2	selenium
7440-22-4	silver

Table I-2
Site 5-Specific Background Soil Sample Results
California Air National Guard - Fresno, California

Sample Number	SB5-01-30.5/31.0		SB5-01-41.0/41.5		SB5-01-48.5-49.0 FD		SB5-01-49.0/49.5		SB5-01-80.5/81.0		SB5-10-15.5/16.0	
Sample Date	2-Oct-92		2-Oct-92		2-Oct-92		2-Oct-92		2-Oct-92		12-Oct-92	
Parameter (µg/kg)	Result Qual	VQual	Result Qual	VQual	Result Qual	VQual	Result Qual	VQual	Result Qual	VQual	Result Qual	VQual
Volatile Organic Compounds:												
1,1,1,2-Tetrachloroethane	0.3 U		0.3 U		0.3 U		0.3 U		0.3 U			
1,1,1-Trichloroethane	0.3 U		0.3 U		0.3 U		0.3 U	R	0.3 U		6 U	
1,1,2,2-Tetrachloroethane	0.3 U		0.3 U		0.3 U		0.3 U		0.3 U		6 U	
1,1,2-Trichloroethane	0.2 U		0.2 U		0.2 U		0.2 U		0.2 U		6 U	
1,1-Dichloroethane	0.7 U		0.7 U		0.7 U		0.7 U		0.7 U		6 U	
1,1-Dichloroethene	1.3 U		1.3 U		1.3 U		1.3 U		1.3 U		6 U	
1,2,3-Trichloropropane	1 U		1 U		1 U		1 U		1 U			
1,2-Dichlorobenzene	1.5 U		1.5 U		1.5 U		1.5 U		1.5 U			
1,2-Dichloroethane	0.3 U		0.3 U		0.3 U		0.3 U		0.3 U		6 U	
1,2-Dichloroethene											6 U	
1,2-Dichloropropane	0.4 U		0.4 U		0.4 U		0.4 U		0.4 U		6 U	
1,3-Dichlorobenzene	3.2 U		3.2 U		3.2 U		3.2 U		3.2 U			
1,4-Dichlorobenzene	2.4 U		2.4 U		2.4 U		2.4 U		2.4 U			
1-Chlorohexane	1 U		1 U		1 U		1 U		1 U			
2-Butanone											12 U	
2-Chloroethylvinyl ether	1.3 U		1.3 U		1.3 U		1.3 U		1.3 U			
2-Hexanone											12 U	
4-Methyl-2-pentanone											12 U	
Acetone											40 B	U
Benzene	2 U		2 U		2 U		2 U		2 U		6 U	
bis(2-Chloroisopropyl) ether	20 U		20 U		20 U		20 U					
Bromobenzene	2 U		2 U		2 U		2 U		2 U			
Bromodichloromethane	1 U		1 U		1 U		1 U		1 U		6 U	
Bromoform	2 U		2 U		2 U		2 U		2 U		6 U	
Bromomethane	1.2 U		1.2 U		1.2 U		1.2 U		1.2 U		12 U	
Carbon disulfide											6 U	
Carbon tetrachloride	1.2 U		1.2 U		1.2 U		1.2 U		1.2 U		6 U	
Chlorobenzene	2 U		2 U		2 U		2 U		2 U		6 U	

Table I-2
Site 5-Specific Background Soil Sample Results
California Air National Guard - Fresno, California

Sample Number	SB5-10-50.5/51.0			SB5-10-85.0/85.5FD			SB5-10-85.5/86.0			Background Range	
Sample Date	12-Oct-92			12-Oct-92			12-Oct-92				
Parameter (µg/kg)	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Min	Max
Volatile Organic Compounds:											
1,1,1,2-Tetrachloroethane										0.3	0.3
1,1,1-Trichloroethane	6	U		6	U		6	U		0.3	6
1,1,2,2-Tetrachloroethane	6	U		6	U		6	U		0.3	6
1,1,2-Trichloroethane	6	U		6	U		6	U		0.2	6
1,1-Dichloroethane	6	U		6	U		6	U		0.7	6
1,1-Dichloroethene	6	U		6	U		6	U		1.3	6
1,2,3-Trichloropropane										1	1
1,2-Dichlorobenzene										1.5	1.5
1,2-Dichloroethane	6	U		6	U		6	U		0.3	6
1,2-Dichloroethene	6	U		6	U		6	U		6	6
1,2-Dichloropropane	6	U		6	U		6	U		0.4	6
1,3-Dichlorobenzene										3.2	3.2
1,4-Dichlorobenzene										2.4	2.4
1-Chlorohexane										1	1
2-Butanone	12	U		13	U		13	U		12	13
2-Chloroethylvinyl ether										1.3	1.3
2-Hexanone	12	U		13	U		13	U		12	13
4-Methyl-2-pentanone	12	U		13	U		13	U		12	13
Acetone	23	B	U	27	B		29	B		23	40
Benzene	6	U		6	U		6	U		2	6
bis(2-Chloroisopropyl) ether										20	20
Bromobenzene										2	2
Bromodichloromethane	6	U		6	U		6	U		1	6
Bromoform	6	U		6	U		6	U		2	6
Bromomethane	12	U		13	U		13	U		1.2	13
Carbon disulfide	6	U		6	U		6	U		6	6
Carbon tetrachloride	6	U		6	U		6	U		1.2	6
Chlorobenzene	6	U		6	U		6	U		2	6

Table I-2
Site 5-Specific Background Soil Sample Results
California Air National Guard - Fresno, California

Sample Number	SB5-01-30.5/31.0			SB5-01-41.0/41.5			SB5-01-48.5-49.0 FD			SB5-01-49.0/49.5			SB5-01-80.5/81.0			SB5-10-15.5/16.0		
Sample Date	2-Oct-92			2-Oct-92			2-Oct-92			2-Oct-92			2-Oct-92			12-Oct-92		
Parameter (µg/kg)	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual
Chloroethane	5.2	U		5.2	U		5.2	U		5.2	U		5.2	U		12	U	
Chloroform	0.5	U		0.5	U		0.5	U		0.5	U		0.5	U		6	U	
Chloromethane	0.8	U		0.8	U		0.8	U		0.8	U		0.8	U		12	U	
Chlorotoluene	1	U		1	U		1	U		1	U		1	U				
cis-1,2-Dichloroethene	1	U		1	U		1	U		1	U		1	U				
cis-1,3-Dichloropropene	3.4	U		3.4	U		3.4	U		3.4	U		3.4	U		6	U	
Dibromochloromethane	0.9	U		0.9	U		0.9	U		0.9	U		0.9	U		6	U	
Dibromomethane	2	U		2	U		2	U		2	U		2	U				
Dichlorodifluoromethane	1.8	U		1.8	U		1.8	U		1.8	U		1.8	U				
Ethylbenzene	2	U		2	U		2	U		2	U		2	U		6	U	
Methylene chloride	15	U		15	U		15	U		15	U		15	U		16	B	U
Tetrachloroethene	0.3	U		0.3	U		0.3	U		0.3	U		0.3	U		6	U	
Toluene	2	U		2	U		2	U		2	U		2	U		6	U	
Total Xylenes	1	U		1	U		1	U		1	U		1	U		6	U	
trans-1,2-Dichloroethene	1	U		1	U		1	U		1	U		1	U				
trans-1,3-Dichloropropene	3.4	U		3.4	U		3.4	U		3.4	U		3.4	U		6	U	
Trichloroethene	1.2	U		1.2	U		1.2	U		1.2	U		1.2	U		6	U	
Trichlorofluoromethane	2	U		2	U		2	U		2	U		2	U				
Vinyl acetate																12	U	
Vinyl chloride	1.8	U		1.8	U		1.8	U		1.8	U		1.8	U		12	U	
Semivolatile Organic Compounds:																		
1,2,4-Trichlorobenzene	350	U		410	U		390	U		410	U		440	U		400	U	
1,2-Dichlorobenzene	350	U		410	U		390	U		410	U		440	U		400	U	
1,3-Dichlorobenzene	350	U		410	U		390	U		410	U		440	U		400	U	
1,4-Dichlorobenzene	350	U		410	U		390	U		410	U		440	U		400	U	
2,4,5-Trichlorophenol	1700	U		2000	U		1900	U		2000	U		2200	U		2000	U	
2,4,6-Trichlorophenol	350	U		410	U		390	U		410	U		440	U		400	U	
2,4-Dichlorophenol	350	U		410	U		390	U		410	U		440	U		400	U	
2,4-Dimethylphenol	350	U		410	U		390	U		410	U		440	U		400	U	

Table I-2
Site 5-Specific Background Soil Sample Results
California Air National Guard - Fresno, California

Sample Number	SB5-10-50.5/51.0			SB5-10-85.0/85.5FD			SB5-10-85.5/86.0				
Sample Date	12-Oct-92			12-Oct-92			12-Oct-92			Background Range	
Parameter (µg/kg)	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Min	Max
Chloroethane	12	U		13	U		13	U		5.2	13
Chloroform	6	U		6	U		6	U		0.5	6
Chloromethane	12	U		13	U		13	U		0.8	13
Chlorotoluene										1	1
cis-1,2-Dichloroethene										1	1
cis-1,3-Dichloropropene	6	U		6	U		6	U		3.4	6
Dibromochloromethane	6	U		6	U		6	U		0.9	6
Dibromomethane										2	2
Dichlorodifluoromethane										1.8	1.8
Ethylbenzene	6	U		6	U		6	U		2	6
Methylene chloride	13	B	U	12	B		12	B	U	12	16
Tetrachloroethene	6	U		6	U		6	U		0.3	6
Toluene	6	U		6	U		6	U		2	6
Total Xylenes	6	U		6	U		6	U		1	6
trans-1,2-Dichloroethene										1	1
trans-1,3-Dichloropropene	6	U		6	U		6	U		3.4	6
Trichloroethene	6	U		4	J		5	J	J	1.2	6
Trichlorofluoromethane										2	2
Vinyl acetate	12	U		13	U		13	U		12	13
Vinyl chloride	12	U		13	U		13	U		1.8	13
Semivolatile Organic Compoun											
1,2,4-Trichlorobenzene	380	U		410	U		420	U		350	440
1,2-Dichlorobenzene	380	U		410	U		420	U		350	440
1,3-Dichlorobenzene	380	U		410	U		420	U		350	440
1,4-Dichlorobenzene	380	U		410	U		420	U		350	440
2,4,5-Trichlorophenol	1800	U		2000	U		2000	U		1700	2200
2,4,6-Trichlorophenol	380	U		410	U		420	U		350	440
2,4-Dichlorophenol	380	U		410	U		420	U		350	440
2,4-Dimethylphenol	380	U		410	U		420	U		350	440

Table I-2
Site 5-Specific Background Soil Sample Results
California Air National Guard - Fresno, California

Sample Number	SB5-01-30.5/31.0			SB5-01-41.0/41.5			SB5-01-48.5-49.0 FD			SB5-01-49.0/49.5			SB5-01-80.5/81.0			SB5-10-15.5/16.0		
Sample Date	2-Oct-92			2-Oct-92			2-Oct-92			2-Oct-92			2-Oct-92			12-Oct-92		
Parameter (µg/kg)	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual
2,4-Dinitrophenol	1700	U		2000	U		1900	U		2000	U		2200	U		2000	U	
2,4-Dinitrotoluene	350	U		410	U		390	U		410	U		440	U		400	U	
2,6-Dinitrotoluene	350	U		410	U		390	U		810	U		440	U		400	U	
2-Chloronaphthalene	350	U		410	U		390	U		410	U		440	U		400	U	
2-Chlorophenol	350	U		410	U		390	U		410	U		440	U		400	U	
2-Methylnaphthalene	350	U		410	U		390	U		410	U		440	U		400	U	
2-Methylphenol	350	U		410	U		390	U		410	U		440	U		400	U	
2-Nitroaniline	1700	U		2000	U		1900	U		2000	U		2200	U		2000	U	
2-Nitrophenol	350	U		410	U		390	U		410	U		440	U		400	U	
3,3'-Dichlorobenzidine	690	U		820	U		790	U		820	U		890	U		810	U	
3-Nitroaniline	1700	U		2000	U		1900	U		2000	U		2200	U		2000	U	
4,6-Dinitro-2-methylphenol	1700	U		2000	U		1900	U		2000	U		2200	U		2000	U	
4-Bromophenylphenyl ether	350	U		410	U		390	U		410	U		440	U		400	U	
4-Chloro-3-methylphenol	350	U		410	U		390	U		410	U		440	U		400	U	
4-Chloroaniline	350	U		410	U		390	U		410	U		440	U		400	U	
4-Chlorophenylphenyl ether	350	U		410	U		390	U		410	U		440	U		400	U	
4-Methylphenol	350	U		410	U		390	U		410	U		440	U		400	U	
4-Nitroaniline	1700	U		2000	U		1900	U		2000	U		2200	U		2000	U	
4-Nitrophenol	1700	U					1900	U		2000	U		2200	U		2000	U	
Acenaphthene	350	U		410	U		390	U		410	U		440	U		400	U	
Anthracene	350	U		410	U		390	U		410	U		440	U		400	U	
Benzo(a)anthracene	350	U		410	U		390	U		410	U		440	U		400	U	
Benzo(a)pyrene	350	U		410	U		390	U		410	U		440	U		400	U	
Benzo(b)fluoranthene	350	U		410	U		390	U		410	U		440	U		400	U	
Benzo(g,h,i)perylene	350	U		410	U		390	U		410	U		440	U		400	U	
Benzo(k)fluoranthene	350	U		410	U		390	U		410	U		440	U		400	U	
Benzoic acid	1700	U		2000	U		1900	U		2000	U		2200	U		2000	U	
Benzyl alcohol	350	U		410	U		390	U		410	U		440	U		400	U	
bis(2-Chloroethoxy)methane	350	U		410	U		390	U		410	U		440	U		400	U	

Table I-2
Site 5-Specific Background Soil Sample Results
California Air National Guard - Fresno, California

Sample Number	SB5-10-50.5/51.0			SB5-10-85.0/85.5FD			SB5-10-85.5/86.0				
Sample Date	12-Oct-92			12-Oct-92			12-Oct-92			Background Range	
Parameter (µg/kg)	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Min	Max
2,4-Dinitrophenol	1800	U		2000	U		2000	U		1700	2200
2,4-Dinitrotoluene	380	U		410	U		420	U		350	440
2,6-Dinitrotoluene	380	U		410	U		420	U		350	810
2-Chloronaphthalene	380	U		410	U		420	U		350	440
2-Chlorophenol	380	U		410	U		420	U		350	440
2-Methylnaphthalene	380	U		410	U		420	U		350	440
2-Methylphenol	380	U		410	U		420	U		350	440
2-Nitroaniline	1800	U		2000	U		2000	U		1700	2200
2-Nitrophenol	380	U		410	U		420	U		350	440
3,3'-Dichlorobenzidine	750	U		820	U		840	U		690	890
3-Nitroaniline	1800	U		2000	U		2000	U		1700	2200
4,6-Dinitro-2-methylphenol	1800	U		2000	U		2000	U		1700	2200
4-Bromophenylphenyl ether	380	U		410	U		420	U		350	440
4-Chloro-3-methylphenol	380	U		410	U		420	U		350	440
4-Chloroaniline	380	U		410	U		420	U		350	440
4-Chlorophenylphenyl ether	380	U		410	U		420	U		350	440
4-Methylphenol	380	U		410	U		420	U		350	440
4-Nitroaniline	1800	U		2000	U		2000	U		1700	2200
4-Nitrophenol	1800	U		2000	U		2000	U		1700	2200
Acenaphthene	380	U		410	U		420	U		350	440
Anthracene	380	U		410	U		420	U		350	440
Benzo(a)anthracene	380	U		410	U		420	U		350	440
Benzo(a)pyrene	380	U		410	U		420	U		350	440
Benzo(b)fluoranthene	380	U		410	U		420	U		350	440
Benzo(g,h,i)perylene	380	U		410	U		420	U		350	440
Benzo(k)fluoranthene	380	U		410	U		420	U		350	440
Benzoic acid	1800	U		2000	U		2000	U		1700	2200
Benzyl alcohol	380	U		410	U		420	U		350	440
bis(2-Chloroethoxy)methane	380	U		410	U		420	U		350	440

Table I-2
Site 5-Specific Background Soil Sample Results
California Air National Guard - Fresno, California

Sample Number	SB5-01-30.5/31.0		SB5-01-41.0/41.5		SB5-01-48.5-49.0 FD		SB5-01-49.0/49.5		SB5-01-80.5/81.0		SB5-10-15.5/16.0	
Sample Date	2-Oct-92		2-Oct-92		2-Oct-92		2-Oct-92		2-Oct-92		12-Oct-92	
Parameter (µg/kg)	Result Qual	VQual	Result Qual	VQual	Result Qual	VQual	Result Qual	VQual	Result Qual	VQual	Result Qual	VQual
bis(2-Chloroethyl)ether	350 U		410 U		390 U		410 U		440 U		400 U	
bis(2-Chloroisopropyl) ether	350 U		410 U		390 U		410 U		440 U		400 U	
bis(2-ethylhexyl) phthalate	70 J	J	870		12000 E	R	7500 E	R	13000 E	R	400 U	
Butyl benzyl phthalate	350 U		410 U		390 U		410 U		440 U		400 U	
Chrysene	350 U		410 U		390 U		410 U		440 U		400 U	
Di-n-butyl phthalate	350 U		410 U		390 U		410 U		440 U		400 U	
Di-n-octyl phthalate	350 U		410 U		390 U		410 U		440 U		400 U	
Dibenzo(a,h)anthracene	350 U		410 U		390 U		410 U		440 U		400 U	
Dibenzofuran	350 U		410 U		390 U		410 U		440 U		400 U	
Diethyl phthalate	350 U		410 U		2000 U		410 U		2200 U		400 U	
Dimethyl phthalate	350 U		410 U		390 U		410 U		440 U		400 U	
Fluoranthene	350 U		410 U		390 U		410 U		440 U		400 U	
Fluorene	350 U		410 U		390 U		410 U		440 U		400 U	
Hexachlorobenzene	350 U		410 U		390 U		410 U		440 U		400 U	
Hexachlorobutadiene	350 U		410 U		390 U		410 U		440 U		400 U	
Hexachlorocyclopentadiene	350 U		410 U		390 U		410 U		440 U		400 U	
Hexachloroethane	350 U		410 U		390 U		410 U		440 U		400 U	
Indeno(1,2,3-cd)pyrene	350 U		410 U		390 U		410 U		440 U		400 U	
Isophorone	350 U		410 U		390 U		410 U		440 U		400 U	
N-Nitroso-di-n-propylamine	350 U		410 U		390 U		410 U		440 U		400 U	
N-Nitrosodiphenylamine	350 U		410 U		390 U		410 U		440 U		400 U	
Naphthalene	350 U		410 U		390 U		410 U		440 U		400 U	
Nitrobenzene	350 U		410 U		390 U		410 U		440 U		400 U	
Pentachlorophenol	1700 U		2000 U		1900 U		2000 U		2200 U		2000 U	
Phenanthrene	350 U		410 U		390 U		410 U		440 U		400 U	
Phenol	350 U		410 U		390 U		410 U		440 U		400 U	
Pyrene	350 U		410 U		390 U		410 U		440 U		400 U	
TPHC-as diesel (mg/kg)	10 U		10 U		10 U		10 U		10 U		10 U	

Table I-2
Site 5-Specific Background Soil Sample Results
California Air National Guard - Fresno, California

Sample Number	SB5-10-50.5/51.0			SB5-10-85.0/85.5FD			SB5-10-85.5/86.0				
Sample Date	12-Oct-92			12-Oct-92			12-Oct-92			Background Range	
Parameter (µg/kg)	Result	Qual	VQual	Result	Qual	VQual	Result	Qual	VQual	Min	Max
bis(2-Chloroethyl)ether	380	U		410	U					350	440
bis(2-Chloroisopropyl) ether	380	U		410	U		420	U		350	440
bis(2-ethylhexyl) phthalate	380	U		410	U		420	U		70	870
Butyl benzyl phthalate	380	U		410	U		420	U		350	440
Chrysene	380	U		410	U		420	U		350	440
Di-n-butyl phthalate	380	U		410	U		420	U		350	440
Di-n-octyl phthalate	380	U		410	U		420	U		350	440
Dibenzo(a,h)anthracene	380	U		410	U		420	U		350	440
Dibenzofuran	380	U		410	U		420	U		350	440
Diethyl phthalate	380	U		410	U					350	2200
Dimethyl phthalate	380	U		410	U		420	U		350	440
Fluoranthene	380	U		410	U		420	U		350	440
Fluorene	380	U		410	U		420	U		350	440
Hexachlorobenzene	380	U		410	U		420	U		350	440
Hexachlorobutadiene	380	U		410	U		420	U		350	440
Hexachlorocyclopentadiene	380	U		410	U		420	U		350	440
Hexachloroethane	380	U		410	U		420	U		350	440
Indeno(1,2,3-cd)pyrene	380	U		410	U		420	U		350	440
Isophorone	380	U		410	U		420	U		350	440
N-Nitroso-di-n-propylamine	380	U		410	U		420	U		350	440
N-Nitrosodiphenylamine	380	U		410	U		420	U		350	440
Naphthalene	380	U		410	U		420	U		350	440
Nitrobenzene	380	U		410	U		420	U		350	440
Pentachlorophenol	1800	U		2000	U		2000	U		1700	2200
Phenanthrene	380	U		410	U		420	U		350	440
Phenol	380	U		410	U		420	U		350	440
Pyrene	380	U		410	U		420	U		350	440
TPHC-as diesel (mg/kg)	10	U		10	U		10	U		10	10

Table I-3
Summary of Detections
Site 2 Groundwater Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
MW2-01-11/90	Tetrachloroethene	µg/L	47	J		11/9/90
MW2-01-02/91	Tetrachloroethene	µg/L	52	J	J	2/6/91
MW2-01-06/92	Tetrachloroethene	µg/L	38			6/28/92
MW2-01-10/92	Tetrachloroethene	µg/L	25			10/22/92
MW2-01-01/93	Tetrachloroethene	µg/L	23			1/19/93
MW2-01-04/93	Tetrachloroethene	µg/L	15			4/19/93
MW2-01-11/90	Trichloroethene	µg/L	27	J		11/9/90
MW2-01-02/91	Trichloroethene	µg/L	20			2/6/91
MW2-01-06/92	Trichloroethene	µg/L	6			6/28/92
MW2-01-10/92	Trichloroethene	µg/L	8.4			10/22/92
MW2-01-01/93	Trichloroethene	µg/L	7			1/19/93
MW2-01-04/93	Trichloroethene	µg/L	3			4/19/93
MW2-02-02/91	Chloroform	µg/L	1.4			2/6/91
MW2-02-11/90	Tetrachloroethene	µg/L	100	J		11/9/90
MW2-02-02/91	Tetrachloroethene	µg/L	85	J	J	2/6/91
MW2-02-06/92	Tetrachloroethene	µg/L	22			6/28/92
MW2-02-10/92	Tetrachloroethene	µg/L	45			10/21/92
MW2-02-01/93	Tetrachloroethene	µg/L	69			1/19/93
MW2-02-04/93	Tetrachloroethene	µg/L	43			4/19/93
MW2-02-10/92	trans-1,2-Dichloroethene	µg/L	7.1			10/21/92
MW2-02-11/90	Trichloroethene	µg/L	21	J		11/9/90
MW2-02-02/91	Trichloroethene	µg/L	9.5			2/6/91
MW2-02-06/92	Trichloroethene	µg/L	3.5			6/28/92
MW2-02-01/93	Trichloroethene	µg/L	6			1/19/93
MW2-02-04/93	Trichloroethene	µg/L	5.9			4/19/93
MW2-03-02/91	Chloroform	µg/L	1.3			2/6/91
MW2-03-11/90	TPHC-as diesel	µg/L	430			11/9/90
MW2-03-11/90	Tetrachloroethene	µg/L	41	J		11/9/90
MW2-03-02/91	Tetrachloroethene	µg/L	80	J	J	2/6/91
MW2-03-06/92	Tetrachloroethene	µg/L	30			6/28/92
MW2-03-10/92	Tetrachloroethene	µg/L	44			10/21/92
MW2-03-01/93	Tetrachloroethene	µg/L	46			1/19/93
MW2-03-04/93	Tetrachloroethene	µg/L	33			4/19/93
MW2-03-04/93Z	Tetrachloroethene	µg/L	33			4/19/93
MW2-03-11/90	Trichloroethene	µg/L	9.1	J		11/9/90
MW2-03-02/91	Trichloroethene	µg/L	11			2/6/91
MW2-03-06/92	Trichloroethene	µg/L	5.1			6/28/92
MW2-03-10/92	Trichloroethene	µg/L	6.6			10/21/92
MW2-03-01/93	Trichloroethene	µg/L	6.5			1/19/93
MW2-03-04/93	Trichloroethene	µg/L	5.8			4/19/93
MW2-03-04/93Z	Trichloroethene	µg/L	5.7			4/19/93
Data not evaluated as a result of the blank correction process:						
MW2-01-10/92	Chloroform	µg/L	1.9	B*		10/22/92
MW2-01-04/93	Chloroform	µg/L	0.7	B*		4/19/93
MW2-02-06/92	TPHC-as diesel	µg/L	230	B*		6/28/92
MW2-02-10/92	Trichloroethene	µg/L	5.6	B*		10/21/92
MW2-03-10/92	cis-1,2-Dichloroethene	µg/L	2.6	B*		10/21/92

NOTES:

Samples with a "Z" suffix are field duplicate samples.

Table I-4
Summary of Detections Base Background Groundwater Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
BMW-1-11/90	bis(2-Ethylhexyl)phthalate	µg/L	5	J		11/14/90
BMW-1-11/90	Chrysene	µg/L	5	J		11/14/90
BMW-1-02/91	Arsenic	µg/L	1.4	B	J	2/13/91
BMW-2-02/91	Arsenic	µg/L	1.7	B	J	2/13/91
BMW-1-11/90	Barium	µg/L	136	J		11/14/90
BMW-1-11/90	Beryllium	µg/L	0.83	J		11/14/90
BMW-1-02/91	Cadmium	µg/L	4.1	B	J	2/13/91
BMW-2-02/91	Cadmium	µg/L	7.8			2/13/91
BMW-2-07/92	Cadmium	µg/L	4			7/1/92
BMW-1-11/90	Chromium	µg/L	4.1	J		11/14/90
BMW-2-07/92	Chromium	µg/L	10.2			7/1/92
BMW-1-11/90	Copper	µg/L	4	J		11/14/90
BMW-2-02/91	Lead	µg/L	1.4	B	J	2/13/91
BMW-1-11/90	Silver	µg/L	2.6	J		11/14/90
BMW-1-11/90	Vanadium	µg/L	19.6	J		11/14/90
BMW-1-11/90	Zinc	µg/L	24.7			11/14/90
Data not evaluated as a result of the blank correction and validation processes:						
BMW-2-07/92	Di-n-butyl phthalate	µg/L	0.6	B*		7/1/92
BMW-2-07/92	Diethyl phthalate	µg/L	1	B*		7/1/92
BMW-1-02/91	Barium	µg/L	129	B	U	2/13/91
BMW-2-02/91	Barium	µg/L	31.5	B	U	2/13/91

Table I-5
Summary of Detections
Site 5 Groundwater Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
MW5-01-10/92	Tetrachloroethene	µg/L	20			10/19/92
MW5-01-01/93	Tetrachloroethene	µg/L	26			1/20/93
MW5-01-04/93	Tetrachloroethene	µg/L	12			4/22/93
MW5-01-10/92	Trichloroethene	µg/L	8.7		N	10/19/92
MW5-01-01/93	Trichloroethene	µg/L	19			1/20/93
MW5-02-10/92	Tetrachloroethene	µg/L	4.1		NJ	10/19/92
MW5-02-01/93	Tetrachloroethene	µg/L	3.5			1/20/93
MW5-02-04/93	Tetrachloroethene	µg/L	3.3			4/22/93
MW5-02-04/93Z	Tetrachloroethene	µg/L	3.1			4/22/93
Data not evaluated as a result of the blank correction and validation processes:						
MW5-01-04/93	Chloroform	µg/L	0.6	B*		4/22/93
MW5-01-04/93	Trichloroethene	µg/L	2.4	B*		4/22/93
MW5-02-10/92	Chloroform	µg/L	0.9	B*	U	10/19/92
MW5-02-01/93	Chloroform	µg/L	0.8	B*	U	1/20/93
MW5-02-04/93	Chloroform	µg/L	1.7	B*		4/22/93
MW5-02-04/93Z	Chloroform	µg/L	1.7	B*		4/22/93

NOTES:

Samples with a "Z" suffix are field duplicate samples.

Table I-6
Summary of Detections
Upgradient Base Perimeter Groundwater Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
MWBP-01-11/90	1,2-Dichloropropane	µg/L	3.3	J		11/9/90
MWBP-01-02/91	1,2-Dichloropropane	µg/L	4			2/12/91
MWBP-01-10/92	1,2-Dichloropropane	µg/L	2.5			10/20/92
MWBP-01-01/93	1,2-Dichloropropane	µg/L	4.6			1/20/93
MWBP-01-04/93	1,2-Dichloropropane	µg/L	3.6			4/20/93
MWBP-01-11/90	Trichloroethene	µg/L	7.7	J		11/9/90
MWBP-01-02/91	Trichloroethene	µg/L	9.8			2/12/91
MWBP-01-06/92	Trichloroethene	µg/L	9.9			6/28/92
MWBP-01-10/92	Trichloroethene	µg/L	8.1			10/20/92
MWBP-01-01/93	Trichloroethene	µg/L	11			1/20/93
MWBP-01-04/93	Trichloroethene	µg/L	9.7			4/20/93
MWBP-02-11/90	1,2-Dichloropropane	µg/L	4.4	J		11/8/90
MWBP-02-02/91	1,2-Dichloropropane	µg/L	5.1			2/12/91
MWBP-02-07/92	1,2-Dichloropropane	µg/L	2.6			7/1/92
MWBP-02-10/92	1,2-Dichloropropane	µg/L	2.7			10/20/92
MWBP-02-01/93Z	1,2-Dichloropropane	µg/L	5.2			1/20/93
MWBP-02-04/93	1,2-Dichloropropane	µg/L	2.9			4/20/93
MWBP-02-11/90	Carbon tetrachloride	µg/L	0.6	J		11/8/90
MWBP-02-11/90	Trichloroethene	µg/L	28	J		11/8/90
MWBP-02-02/91	Trichloroethene	µg/L	37			2/12/91
MWBP-02-07/92	Trichloroethene	µg/L	32			7/1/92
MWBP-02-10/92	Trichloroethene	µg/L	45			10/20/92
MWBP-02-01/93	Trichloroethene	µg/L	49			1/20/93
MWBP-02-01/93Z	Trichloroethene	µg/L	48			1/20/93
MWBP-02-04/93	Trichloroethene	µg/L	30			4/20/93
MWBP-03-11/90	1,2-Dichloropropane	µg/L	6.9	J		11/8/90
MWBP-03-02/91	1,2-Dichloropropane	µg/L	4.8			2/12/91
MWBP-03-6/92	1,2-Dichloropropane	µg/L	5			6/30/92
MWBP-03-6/92Z	1,2-Dichloropropane	µg/L	5			6/30/92
MWBP-03-10/92	1,2-Dichloropropane	µg/L	4.9			10/20/92
MWBP-03-01/93	1,2-Dichloropropane	µg/L	13			1/20/93
MWBP-03-04/93	1,2-Dichloropropane	µg/L	7			4/20/93
MWBP-03-11/90	Carbon tetrachloride	µg/L	0.8	J		11/8/90
MWBP-03-6/92	Di-n-butyl phthalate	µg/L	2	BJ		6/30/92
MWBP-03-6/92Z	Diethyl phthalate	µg/L	2	J		6/30/92
MWBP-03-11/90	Trichloroethene	µg/L	140	J		11/8/90
MWBP-03-02/91	Trichloroethene	µg/L	210	D		2/12/91
MWBP-03-6/92	Trichloroethene	µg/L	140			6/30/92
MWBP-03-6/92Z	Trichloroethene	µg/L	140			6/30/92
MWBP-03-10/92	Trichloroethene	µg/L	170			10/20/92
MWBP-03-01/93	Trichloroethene	µg/L	130			1/20/93
MWBP-03-04/93	Trichloroethene	µg/L	160			4/20/93
MWBP-04-11/90	1,2-Dichloropropane	µg/L	1.1	J		11/8/90
MWBP-04-6/92	Bis(2-ethylhexyl)phthalate	µg/L	0.5	BJ		6/30/92
MWBP-04-6/92	Di-n-butyl phthalate	µg/L	0.9	BJ		6/30/92
MWBP-04-6/92	Diethyl phthalate	µg/L	0.7	J		6/30/92
MWBP-04-11/90	Trichloroethene	µg/L	3.3	J		11/8/90
MWBP-04-02/91	Trichloroethene	µg/L	3.7			2/12/91

Table I-6
Summary of Detections
Upgradient Base Perimeter Groundwater Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
MWBP-04-6/92	Trichloroethene	µg/L	2			6/30/92
MWBP-04-04/93	Trichloroethene	µg/L	2.6			4/20/93
MWBP-09-09/92	Trichloroethene	µg/L	450			9/21/92
MWBP-09-01/93	Trichloroethene	µg/L	520			1/21/93
MWBP-09-04/93	Trichloroethene	µg/L	450			4/21/93
MWBP-10-10/92	1,2-Dichloropropane	µg/L	2.4			10/19/92
MWBP-10-01/93	1,2-Dichloropropane	µg/L	2.5			1/21/93
MWBP-10-04/93	1,2-Dichloropropane	µg/L	2.9			4/21/93
MWBP-10-10/92	Trichloroethene	µg/L	36		J	10/19/92
MWBP-10-01/93	Trichloroethene	µg/L	29			1/21/93
MWBP-10-04/93	Trichloroethene	µg/L	30			4/21/93
Data not evaluated as a result of the blank correction and validation processes:						
MWBP-01-02/91	Methylene chloride	µg/L	39	B*	UJ	2/12/91
MWBP-01-06/92	1,2-Dichloropropane	µg/L	2.4	B*		6/28/92
MWBP-01-06/92	Di-n-butyl phthalate	µg/L	0.8	B*		6/28/92
MWBP-02-10/92	1,2,3-Trichloropropane	µg/L	1.3	B*		10/20/92
MWBP-02-01/93	1,2-Dichloropropane	µg/L	0.5	B*		1/20/93
MWBP-02-02/91	Carbon tetrachloride	µg/L	0.8	B*		2/12/91
MWBP-02-07/92	Carbon tetrachloride	µg/L	0.6	B*		7/1/92
MWBP-02-01/93	Carbon tetrachloride	µg/L	0.9	B*		1/20/93
MWBP-02-01/93Z	Carbon tetrachloride	µg/L	0.8	B*		1/20/93
MWBP-02-04/93	Carbon tetrachloride	µg/L	0.7	B*		4/20/93
MWBP-02-07/92	Di-n-butyl phthalate	µg/L	0.6	B*		7/1/92
MWBP-02-10/92	Dibromomethane	µg/L	2.9	B*		10/20/92
MWBP-02-07/92	Diethyl phthalate	µg/L	0.5	B*		7/1/92
MWBP-02-02/91	Methylene chloride	µg/L	37	B*	UJ	2/12/91
MWBP-03-02/91	Carbon tetrachloride	µg/L	0.8	B*		2/12/91
MWBP-03-02/91	Methylene chloride	µg/L	38	B*	UJ	2/12/91
MWBP-03-10/92	1,2,3-Trichloropropane	µg/L	1.4	B*		10/20/92
MWBP-04-02/91	1,2-Dichloropropane	µg/L	0.9	B*		2/12/91
MWBP-04-10/92	1,2-Dichloropropane	µg/L	0.6	B*		10/20/92
MWBP-04-02/91	Methylene chloride	µg/L	35	B*	UJ	2/12/91
MWBP-04-10/92	Trichloroethene	µg/L	2.8	B*		10/20/92
MWBP-04-01/93	Trichloroethene	µg/L	2	B*		1/20/93
MWBP-09-09/92	Dichlorodifluoromethane	µg/L	3.2	B*		
MWBP-10-01/93	Carbon tetrachloride	µg/L	0.7	B*		1/21/93
MWBP-10-04/93	Carbon tetrachloride	µg/L	1	B*		4/21/93
MWBP-10-10/92	1,2,3-Trichloropropane	µg/L	1.3	B*	R	10/19/92

NOTES:

Samples with a "Z" suffix are field duplicate samples.

Table I-7
Summary of Detections
Downgradient Base Perimeter Groundwater Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
MWBP-05-07/92Z	Bis(2-ethylhexyl)phthalate	µg/L	0.5	BJ		7/1/92
MWBP-05-10/92	cis-1,2-Dichloroethene	µg/L	13			10/21/92
MWBP-05-11/90	Tetrachloroethene	µg/L	110			11/12/90
MWBP-05-02/91	Tetrachloroethene	µg/L	110	D		2/11/91
MWBP-05-07/92	Tetrachloroethene	µg/L	60			7/1/92
MWBP-05-07/92Z	Tetrachloroethene	µg/L	69			7/1/92
MWBP-05-10/92	Tetrachloroethene	µg/L	82			10/21/92
MWBP-05-01/93	Tetrachloroethene	µg/L	50			1/21/93
MWBP-05-04/93	Tetrachloroethene	µg/L	57			4/20/93
MWBP-05-11/90	Trichloroethene	µg/L	35			11/12/90
MWBP-05-02/91	Trichloroethene	µg/L	29			2/11/91
MWBP-05-07/92	Trichloroethene	µg/L	35			7/1/92
MWBP-05-07/92Z	Trichloroethene	µg/L	41			7/1/92
MWBP-05-10/92	Trichloroethene	µg/L	39			10/21/92
MWBP-05-01/93	Trichloroethene	µg/L	37			1/21/93
MWBP-05-04/93	Trichloroethene	µg/L	31			4/20/93
MWBP-06A-11/90	1,2-Dichloropropane	µg/L	0.5	J		11/12/90
MWBP-06A-02/91	Bis(2-ethylhexyl)phthalate	µg/L	2	J		2/11/91
MWBP-06A-11/90	Chrysene	µg/L	3	J		11/12/90
MWBP-06A-11/90	Tetrachloroethene	µg/L	1.7	J		11/12/90
MWBP-06A-02/91	Tetrachloroethene	µg/L	5.4			2/11/91
MWBP-06A-07/92	Tetrachloroethene	µg/L	5			7/1/92
MWBP-06A-10/92	Tetrachloroethene	µg/L	3.2			10/20/92
MWBP-06A-01/93	Tetrachloroethene	µg/L	6.2			1/21/93
MWBP-06A-01/93Z	Tetrachloroethene	µg/L	6			1/21/93
MWBP-06A-04/93	Tetrachloroethene	µg/L	5.8			4/20/93
MWBP-06A-11/90	Trichloroethene	µg/L	0.7	J		11/12/90
MWBP-07	No positive detections in 6 samples.					
MWBP-08-02/91	Bis(2-ethylhexyl)phthalate	µg/L	7	J		2/8/91
MWBP-08-11/90	Chrysene	µg/L	6	J		11/12/90
MWBP-08-11/90	Tetrachloroethene	µg/L	1.2	J		11/12/90
MWBP-08-02/91	Tetrachloroethene	µg/L	1			2/8/91
MWBP-08-07/92	Tetrachloroethene	µg/L	3			7/1/92
MWBP-08-10/92	Tetrachloroethene	µg/L	2			10/20/92
MWBP-11-09/92	1,2-Dichloropropane	µg/L	2.4			9/21/92
MWBP-11-01/93	1,2-Dichloropropane	µg/L	4.1			1/20/93
MWBP-11-04/93Z	1,2-Dichloropropane	µg/L	0.7			4/22/93
MWBP-11-09/92	Trichloroethene	µg/L	16			9/21/92
MWBP-11-01/93	Trichloroethene	µg/L	27			1/20/93
MWBP-11-04/93	Trichloroethene	µg/L	7			4/22/93
MWBP-11-04/93Z	Trichloroethene	µg/L	6.4			4/22/93
MWBP-12-10/92	Tetrachloroethene	µg/L	1.5		J	10/19/92
MWBP-12-01/93	Trichloroethene	µg/L	12			1/20/93
MWBP-12-04/93	Trichloroethene	µg/L	5.5			4/22/93

Table I-7
Summary of Detections
Downgradient Base Perimeter Groundwater Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
Data not evaluated as a result of the blank correction process:						
MWBP-05-01/93	1,2-Dichloropropane	ug/L	1.3	B*		1/21/93
MWBP-05-04/93	1,2-Dichloropropane	ug/L	1	B*		4/20/93
MWBP-05-07/92	1,2-Dichloropropane	ug/L	1	B*		7/1/92
MWBP-05-07/92Z	1,2-Dichloropropane	ug/L	1	B*		7/1/92
MWBP-05-10/92	Carbon tetrachloride	ug/L	5	B*		10/21/92
MWBP-05-02/91	Chloroform	ug/L	1.1	B*		2/11/91
MWBP-05-07/92	Di-n-butyl phthalate	ug/L	0.5	B*		7/1/92
MWBP-05-07/92Z	Di-n-butyl phthalate	ug/L	0.5	B*		7/1/92
MWBP-06A-07/92	Bis(2-ethylhexyl)phthalate	ug/L	1	B*		7/1/92
MWBP-06A-02/91	Trichloroethene	ug/L	0.5	B*		2/11/91
MWBP-07-07/92	Bis(2-ethylhexyl)phthalate	ug/L	0.9	B*		7/1/92
MWBP-07-07/92	Diethyl phthalate	ug/L	0.7	B*		7/1/92
MWBP-07-01/93	Tetrachloroethene	ug/L	0.5	B*		1/21/93
MWBP-07-04/93	Tetrachloroethene	ug/L	1.1	B*		4/20/93
MWBP-07-07/92	Tetrachloroethene	ug/L	1.5	B*		7/1/92
MWBP-07-10/92	Tetrachloroethene	ug/L	0.6	B*		10/20/92
MWBP-08-07/92	Bis(2-ethylhexyl)phthalate	ug/L	1	B*		7/1/92
MWBP-08-07/92	Diethyl phthalate	ug/L	0.5	B*		7/1/92
MWBP-08-01/93	Tetrachloroethene	ug/L	2.4	B*		1/20/93
MWBP-08-04/93	Tetrachloroethene	ug/L	1.9	B*		4/20/93
MWBP-11-04/93	1,2-Dichloropropane	ug/L	0.8	B*		4/22/93
MWBP-11-09/92	Dichlorodifluoromethane	ug/L	4.8	B*		9/21/92
MWBP-12-10/92	1,1-Dichloroethane	ug/L	3	B*		10/19/92
MWBP-12-01/93	1,2-Dichloropropane	ug/L	1.4	B*		1/20/93
MWBP-12-04/93	1,2-Dichloropropane	ug/L	0.9	B*		4/22/93
MWBP-12-01/93	Tetrachloroethene	ug/L	2	B*		1/20/93
MWBP-12-04/93	Tetrachloroethene	ug/L	1.6	B*		4/22/93
MWBP-12-10/92	Trichloroethene	ug/L	4.7	B*		10/19/92

NOTES:

Samples with a "Z" suffix are field duplicate samples.

Table I-8
Summary of Detections
Deep Monitoring Well Groundwater Samples
California Air National Guard - Fresno, California

Area ID	Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
Base Perimeter - Upgradient	MWBP-09B-12/93	Trichloroethene	µg/L	500			12/8/93
	MWBP-09B-12/93Z	Trichloroethene	µg/L	520			12/8/93
	MWBP-09B-2/95	Trichloroethene	µg/L	350			2/14/95
	MWBP-09C-12/93	Trichloroethene	µg/L	25			12/8/93
	MWBP-09C-2/95	Trichloroethene	µg/L	12			2/14/95
Site 5	MW5-01B-1293	Trichloroethene	µg/L	250			12/8/93
	MW5-01B-2/95	Trichloroethene	µg/L	200			2/14/95
	MW5-01C-12/93	Trichloroethene	µg/L	120			12/9/93
	MW5-01C-2/95	Trichloroethene	µg/L	81			2/15/95
Base Perimeter - Downgradient	MWBP-06B-12/93	Tetrachloroethene	µg/L	23			12/9/93
	MWBP-06B-2/95	Tetrachloroethene	µg/L	18			2/15/95
	MWBP-06B-12/93	Trichloroethene	µg/L	7.5			12/9/93
	MWBP-06B-2/95	Trichloroethene	µg/L	4.8			2/15/95
	MWBP-06C-12/93	Trichloroethene	µg/L	260			12/9/93
	MWBP-06C-2/95	Trichloroethene	µg/L	60			2/15/95
	MWBP-05B-12/93	Tetrachloroethene	µg/L	16			12/9/93
	MWBP-05B-2/95	Tetrachloroethene	µg/L	9.8			2/15/95
	MWBP-05B-12/93	Trichloroethene	µg/L	130			12/9/93
	MWBP-05B-2/95	Trichloroethene	µg/L	56			2/15/95
	MWBP-05C-12/93	1,2-Dichloropropane	µg/L	3.9			12/9/93
	MWBP-05C-12/93	Trichloroethene	µg/L	62			12/9/93
	MWBP-05C-2/95	Trichloroethene	µg/L	53			2/16/95

Data not evaluated as a result of the blank correction process:

	Sample ID	Parameter	Units	Results	Lab Qual	Valid Qual	Sample Date
	MWBP-06B-12/93	1,2-Dichloropropane	µg/L	0.88	B*		12/9/93
	MWBP-06B-12/93	cis-1,2-Dichloroethene	µg/L	1.2	B*		12/9/93
	MWBP-06B-2/95	cis-1,2-Dichloroethene	µg/L	0.66	B*		2/15/95

NOTES:

Samples with a "Z" suffix are field duplicate samples.

Table I-9
Summary of Detections
Site 5-BCP Confirmation Soil Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Result	Lab Qual	Valid Qual	Sample Date
SB5-11-85.5/86.0	Acetone	µg/kg	550	BE	J	10/13/92
SB5-11-85.5/86.0	Acetone	µg/kg	220	BD	J	10/13/92
SB5-11-85/85.5	Acetone	µg/kg	300	B	J	10/13/92
SB5-12-80.5/81.0	Acetone	µg/kg	100	B		10/15/92
SB5-01-30.5/31.0	bis(2-ethylhexyl) phthalate	µg/kg	70	J	J	10/2/92
SB5-01-41.0/41.5	bis(2-ethylhexyl) phthalate	µg/kg	870			10/2/92
SB5-02-41.0/41.5	bis(2-ethylhexyl) phthalate	µg/kg	41	J		9/29/92
SB5-02-64.0/64.5	bis(2-ethylhexyl) phthalate	µg/kg	52	J		9/29/92
SB5-02-72.5/73.0	bis(2-ethylhexyl) phthalate	µg/kg	2200			9/29/92
SB5-03-19.0/19.5	bis(2-ethylhexyl) phthalate	µg/kg	60	J	J	9/24/92
SB5-03-34.0/34.5	bis(2-ethylhexyl) phthalate	µg/kg	87	J	J	9/24/92
SB5-03-64.0/64.5	bis(2-ethylhexyl) phthalate	µg/kg	66	J	J	9/24/92
SB5-03-9.0/9.5	bis(2-ethylhexyl) phthalate	µg/kg	96	J	J	9/24/92
SB5-04-29.5/30.0	bis(2-ethylhexyl) phthalate	µg/kg	6200			9/28/92
SB5-04-59.0/59.5	bis(2-ethylhexyl) phthalate	µg/kg	6100			9/28/92
SB5-05-29.0/29.5	bis(2-ethylhexyl) phthalate	µg/kg	55	J		9/23/92
SB5-07-17.0/17.5	bis(2-ethylhexyl) phthalate	µg/kg	260	J	J	9/24/92
SB5-07-29.0/29.5	bis(2-ethylhexyl) phthalate	µg/kg	150	J	J	9/24/92
SB5-07-44.0/44.5	bis(2-ethylhexyl) phthalate	µg/kg	190	J	J	9/24/92
SB5-07-64.0/64.5	bis(2-ethylhexyl) phthalate	µg/kg	81	J	J	9/24/92
SB5-04-59.0/59.5	Di-n-butyl phthalate	µg/kg	47	J	J	9/28/92
SB5-05-22.0/22.5	Diethyl phthalate	µg/kg	360	J		9/23/92
SB5-05-64.0/64.5	Diethyl phthalate	µg/kg	530			9/23/92
SB5-06-24.0/24.5	Diethyl phthalate	µg/kg	350	J		9/29/92
SB5-06-24.0/24.5	Diethyl phthalate	µg/kg	350	J		9/29/92
SB5-06-29.0/29.5	Diethyl phthalate	µg/kg	1400			9/29/92
SB5-06-29.0/29.5	Diethyl phthalate	µg/kg	1400			9/29/92
SB5-11-85.5/86.0	Methylene chloride	µg/kg	45	B	J	10/13/92
SB5-11-85.5/86.0	Methylene chloride	µg/kg	25	BD	J	10/13/92
SB5-11-85/85.5	Methylene chloride	µg/kg	85	B	J	10/13/92
SB5-10-85.5/86.0	Trichloroethene	µg/kg	5	J	J	10/12/92
Shallow Soil Samples:						
SS-1A	Acetone	µg/kg	24			2/7/91
SS-4A	Benzo(a)pyrene	µg/kg	100	J		2/7/91
SS-4A	Benzo(b)fluoranthene	µg/kg	130	J		2/7/91
SS-4A	Benzo(k)fluoranthene	µg/kg	130	J		2/7/91
SS-2A	Bis(2-ethylhexyl)phthalate	µg/kg	89	J		2/7/91
SS-3A	Bis(2-ethylhexyl)phthalate	µg/kg	140	J	NJ	2/7/91
SS-4A	Bis(2-ethylhexyl)phthalate	µg/kg	140	J		2/7/91
SS-4A	Chrysene	µg/kg	110	J		2/7/91
SS-2A	TPHC - as diesel	mg/kg	28	Z	J	2/7/91
SS-4A	TPHC - as diesel	mg/kg	20	Z	J	2/7/91
SS-4B	Diethyl phthalate	µg/kg	59	J		2/7/91
SS-3A	Fluoranthene	µg/kg	97	J		2/7/91
SS-4A	Fluoranthene	µg/kg	130	J		2/7/91

Table I-9
Summary of Detections
Site 5-BCP Confirmation Soil Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Result	Lab Qual	Valid Qual	Sample Date
SS-3A	Indeno(1,2,3-cd)pyrene	µg/kg	40	J		2/7/91
SS-4A	Indeno(1,2,3-cd)pyrene	µg/kg	82	J		2/7/91
SS-4A	Methylene chloride	µg/kg	10	B		2/7/91
SS-4A	Phenanthrene	µg/kg	52	J		2/7/91
SS-2A	Pyrene	µg/kg	50	J		2/7/91
SS-3A	Pyrene	µg/kg	86	J		2/7/91
SS-4A	Pyrene	µg/kg	130	J		2/7/91
Data not evaluated as a result of data validation:						
SB5-10-15.5/16.0	Acetone	µg/kg	40	B	U	10/12/92
SB5-10-50.5/51.0	Acetone	µg/kg	23	B	U	10/12/92
SB5-10-85.5/86.0	Acetone	µg/kg	29	B	U	10/12/92
SB5-01-49.0/49.5	bis(2-ethylhexyl) phthalate	µg/kg	7500	E	R	10/2/92
SB5-01-49.0/49.5	bis(2-ethylhexyl) phthalate	µg/kg	7100	D	R	10/2/92
SB5-01-80.5/81.0	bis(2-ethylhexyl) phthalate	µg/kg	13000	E	R	10/2/92
SB5-01-80.5/81.0	bis(2-ethylhexyl) phthalate	µg/kg	12000	D	R	10/2/92
SB5-04-19.0/19.5	bis(2-ethylhexyl) phthalate	µg/kg	7900	E	R	9/28/92
SB5-04-19.0/19.5	bis(2-ethylhexyl) phthalate	µg/kg	8500	D	R	9/28/92
SB5-03-19.0/19.5	Methylene chloride	µg/kg	26		U	9/24/92
SB5-10-15.5/16.0	Methylene chloride	µg/kg	16	B	U	10/12/92
SB5-10-50.5/51.0	Methylene chloride	µg/kg	13	B	U	10/12/92
SB5-10-85.5/86.0	Methylene chloride	µg/kg	12	B	U	10/12/92
SB5-12-80.5/81.0	Methylene chloride	µg/kg	15	B	U	10/15/92
SS-2A	Acetone	µg/kg	12	J	U	2/7/91
SS-2B	Acetone	µg/kg	18		U	2/7/91
SS-3A	Acetone	µg/kg	8	J	U	2/7/91
SS-3B	Acetone	µg/kg	11	J	U	2/7/91
SS-4B	Acetone	µg/kg	39		U	2/7/91
SS-3A	Benzo(b)fluoranthene	µg/kg	75	J	U	2/7/91
SS-3A	Benzo(k)fluoranthene	µg/kg	77	J	U	2/7/91
SS-1A	Methylene chloride	µg/kg	16	B	U	2/7/91
SS-1B	Methylene chloride	µg/kg	15	B	U	2/7/91
SS-2A	Methylene chloride	µg/kg	16	B	U	2/7/91
SS-2B	Methylene chloride	µg/kg	21	B	U	2/7/91
SS-3A	Methylene chloride	µg/kg	17	B	U	2/7/91
SS-3B	Methylene chloride	µg/kg	18	B	U	2/7/91
SS-4B	Methylene chloride	µg/kg	14	B	U	2/7/91

Table I-10
Summary of Detections
Site Investigation Background Boring Soil Samples
California Air National Guard - Fresno, California

Sample ID	Parameter	Units	Result	Lab Qual	Valid Qual	Sample Date
SBB1-65.0-66.5	Arsenic	mg/kg	0.46	J		8/1/90
SBB1-03.0-04.5	Barium	mg/kg	47.9			7/31/90
SBB1-07.8-08.8	Barium	mg/kg	56.3			7/31/90
SBB1-15.4-16.65	Barium	mg/kg	135			7/31/90
SBB1-18.6-20.0	Barium	mg/kg	233			7/31/90
SBB1-28.5-30.0	Barium	mg/kg	122			7/31/90
SBB1-30.0-31.5FD	Barium	mg/kg	120			7/31/90
SBB1-38.5-40.0	Barium	mg/kg	74.6			7/31/90
SBB1-48.5-50.0	Barium	mg/kg	79.2			7/31/90
SBB1-63.5-65.0	Barium	mg/kg	75.1			8/1/90
SBB1-65.0-66.5	Barium	mg/kg	54.2			8/1/90
SBB1-15.4-16.65	Chromium	mg/kg	25.9			7/31/90
SBB1-18.6-20.0	Chromium	mg/kg	49.6			7/31/90
SBB1-28.5-30.0	Chromium	mg/kg	27.9			7/31/90
SBB1-30.0-31.5FD	Chromium	mg/kg	22.5			7/31/90
SBB1-65.0-66.5	Chromium	mg/kg	3.1			8/1/90
SBB1-15.4-16.65	Lead	mg/kg	10.6	J		7/31/90
SBB1-18.6-20.0	Lead	mg/kg	5.6	J		7/31/90
SBB1-30.0-31.5FD	Lead	mg/kg	3.5	J		7/31/90
SBB1-65.0-66.5	Lead	mg/kg	4.7	J		8/1/90
SBB1-15.4-16.65	Silver	mg/kg	1.2	J		7/31/90
SBB1-18.6-20.0	Silver	mg/kg	2.2	J		7/31/90
SBB1-30.0-31.5FD	Silver	mg/kg	1	J		7/31/90
SBB1-65.0-66.5	Silver	mg/kg	0.82	J		8/1/90
SBB1-03.0-04.5	Acetone	µg/kg	36			7/31/90
SBB1-30.0-31.5FD	bis(2-ethylhexyl)phthalate	µg/kg	580			7/31/90
SBB1-38.5-40.0	bis(2-ethylhexyl)phthalate	µg/kg	97 J			7/31/90
Data not evaluated as a result of the blank correction and validation processes:						
SBB1-03.0-04.5	Arsenic	mg/kg	0.73	B*		7/31/90
SBB1-03.0-04.5	Chromium	mg/kg	12.6	B*		7/31/90
SBB1-03.0-04.5	Lead	mg/kg	1.9	B*		7/31/90
SBB1-03.0-04.5	Silver	mg/kg	0.92	B*		7/31/90
SBB1-07.8-08.8	Arsenic	mg/kg	0.92	B*		7/31/90
SBB1-07.8-08.8	Chromium	mg/kg	13	B*		7/31/90
SBB1-07.8-08.8	Lead	mg/kg	9.4	B*		7/31/90
SBB1-07.8-08.8	Silver	mg/kg	0.88	B*		7/31/90
SBB1-28.5-30.0	Lead	mg/kg	4.2	B*		7/31/90
SBB1-28.5-30.0	Silver	mg/kg	1.4	B*		7/31/90
SBB1-38.5-40.0	Arsenic	mg/kg	0.23	B*		7/31/90
SBB1-38.5-40.0	Chromium	mg/kg	9.2	B*		7/31/90
SBB1-38.5-40.0	Lead	mg/kg	3.5	B*		7/31/90
SBB1-38.5-40.0	Silver	mg/kg	1.1	B*		7/31/90
SBB1-48.5-50.0	Chromium	mg/kg	4.9	B*		7/31/90
SBB1-48.5-50.0	Lead	mg/kg	4.9	B*		7/31/90
SBB1-63.5-65.0	Arsenic	mg/kg	0.32	B*		8/1/90
SBB1-63.5-65.0	Chromium	mg/kg	8	B*		8/1/90
SBB1-63.5-65.0	Lead	mg/kg	4.7	B*		8/1/90
SBB1-65.0-66.5DL	1,2-Dichloropropane	µg/kg	5		R	8/1/90

Table I-11a
Detection Limit Ranges for RI Groundwater Samples
Fresno Air National Guard, Fresno, California

Parameter	Detection Limits (µg/L) Min.	Max.
Pesticides/PCBs (CLP)		
4,4'-DDD	0.1	0.1
4,4'-DDE	0.1	0.1
4,4'-DDT	0.1	0.1
Aldrin	0.05	0.05
alpha-BHC	0.05	0.05
alpha-Chlordane	0.05	0.50
Arochlor-1016	1.0	1.0
Arochlor-1221	2.0	2.0
Arochlor-1232	1.0	1.0
Arochlor-1242	1.0	1.0
Arochlor-1248	1.0	1.0
Arochlor-1254	1.0	1.0
Arochlor-1260	1.0	1.0
beta-BHC	0.05	0.05
Carbazole	10	10
delta-BHC	0.05	0.05
Dieldrin	0.1	0.1
Endosulfan I	0.05	0.05
Endosulfan II	0.1	0.1
Endosulfan sulfate	0.1	0.1
Endrin	0.1	0.1
Endrin aldehyde	0.1	0.1
Endrin ketone	0.1	0.1
gamma-BHC (Lindane)	0.05	0.05
gamma-Chlordane	0.05	0.50
Heptachlor	0.05	0.05
Heptachlor epoxide	0.05	0.05
Methoxychlor	0.50	0.50
Toxaphene	1.0	5.0
Semivolatile Organics (CLP)		
1,2,4-Trichlorobenzene	10	10
1-Chlorohexane	1	1
2,4,5-Trichlorophenol	25	50
2,4,6-Trichlorophenol	10	10
2,4-Dichlorophenol	10	10
2,4-Dimethylphenol	10	10
2,4-Dinitrophenol	25	50
2,4-Dinitrotoluene	10	10
2,6-Dinitrotoluene	10	10
2-Chloroethylvinyl ether	0.5	10
2-Chloronaphthalene	10	10
2-Chlorophenol	10	10
2-Methylnaphthalene	10	10
2-Methylphenol	10	10
2-Nitroaniline	25	50

Table I-11a
Detection Limit Ranges for RI Groundwater Samples
Fresno Air National Guard, Fresno, California

Parameter	Detection Limits (µg/L) Min.	Max.
2-Nitrophenol	10	10
3,3'-Dichlorobenzidine	10	20
3-Nitroaniline	25	50
4,6-Dinitro-2-methylphenol	25	50
4-Bromophenylphenyl ether	10	10
4-Chloro-3-methylphenol	10	10
4-Chloroaniline	10	10
4-Chlorophenylphenyl ether	10	10
4-Methylphenol	10	10
4-Nitroaniline	25	50
4-Nitrophenol	25	50
Acenaphthene	10	10
Anthracene	10	10
Benzo(a)anthracene	10	10
Benzo(a)pyrene	10	10
Benzo(b)fluoranthene	10	10
Benzo(g,h,i)perylene	10	10
Benzo(k)fluoranthene	10	10
Benzoic acid	50	50
Benzyl alcohol	10	10
Bis(2-chloroethoxy)methane	10	10
Bis(2-chloroethyl)ether	10	10
bis(2-Chloroisopropyl)ether	10	20
bis(2-Ethylhexyl)phthalate	10	10
Butyl benzyl phthalate	10	10
Chrysene	10	10
Di-n-butyl phthalate	10	10
Di-n-octyl phthalate	10	10
Dibenzo(a,h)anthracene	10	10
Dibenzofuran	10	10
Diethyl phthalate	10	10
Dimethyl phthalate	10	10
Fluoranthene	10	10
Fluorene	10	10
Hexachlorobenzene	10	10
Hexachlorobutadiene	10	10
Hexachlorocyclopentadiene	10	10
Hexachloroethane	10	10
Indeno(1,2,3-cd)pyrene	10	10
Isophorone	10	10
N-Nitroso-di-n-propylamine	10	10
N-Nitrosodiphenylamine	10	10
Naphthalene	10	10
Nitrobenzene	10	10
Pentachlorophenol	25	50
Phenanthrene	10	10

Table I-11a
Detection Limit Ranges for RI Groundwater Samples
Fresno Air National Guard, Fresno, California

Parameter	Detection Limits (µg/L) Min.	Max.
Phenol	10	10
Pyrene	10	10
TPHC-as diesel	50	250
Volatile Organics (8010/8020)		
1,1,1,2-Tetrachloroethane	0.3	0.3
1,1,1-Trichloroethane	0.5	10
1,1,2,2-Tetrachloroethane	0.5	10
1,1,2-Trichloroethane	0.5	10
1,1-Dichloroethane	0.5	10
1,1-Dichloroethene	0.5	10
1,2,3-Trichloropropane	1	1
1,2-Dichlorobenzene	0.5	10
1,2-Dichloroethane	0.5	3
1,2-Dichloropropane	0.5	10
1,3-Dichlorobenzene	0.5	10
1,4-Dichlorobenzene	0.5	10
Benzene	0.5	2
Bromobenzene	2	2
Bromodichloromethane	0.5	10
Bromoform	0.5	10
Bromomethane	0.5	10
Carbon Tetrachloride	0.5	10
Chlorobenzene	0.5	10
Chloroethane	0.5	10
Chloroform	0.5	10
Chloromethane	0.5	10
Chlorotoluene	1	1
cis-1,2-Dichloroethene	1	1
cis-1,3-Dichloropropene	0.5	10
Dibromochloromethane	0.5	10
Dibromomethane	2	2.3
Dichlorodifluoromethane	0.5	10
Ethylbenzene	0.5	2
Methylene chloride	0.5	300
Tetrachloroethene	0.5	10
Toluene	0.5	2
trans-1,2-Dichloroethene	0.5	10
trans-1,3-Dichloropropene	0.5	10
Trichloroethene	0.5	6
Trichlorofluoromethane	0.5	10
Vinyl chloride	0.5	10
Xylenes (total)	1	1

Table I-11b
Detection Limit Ranges for Site 5 RI Soil Samples
Fresno Air National Guard, Fresno, California

Parameter	Detection Limits (µg/kg) Min.	Max.
Volatile Organics (CLP)		
1,1,1,2-Tetrachloroethane	0.3	5
1,1,1-Trichloroethane	0.3	17
1,1,2,2-Tetrachloroethane	0.3	17
1,1,2-Trichloroethane	0.2	17
1,1-Dichloroethane	0.7	17
1,1-Dichloroethene	1.3	17
1,2,3-Trichloropropane	1	5
1,2-Dichlorobenzene	1.5	2200
1,2-Dichloroethane	0.3	17
1,2-Dichloroethene	5	17
1,2-Dichloropropane	0.4	17
1,3-Dichlorobenzene	3.2	2200
1,4-Dichlorobenzene	2.4	2200
1-Chlorohexane	1	5
2-Butanone	10	34
2-Chloroethylvinyl ether	1.3	5
2-Hexanone	10	34
4-Methyl-2-pentanone	10	34
Acetone	10	34
Benzene	2	17
Bromobenzene	1	2
Bromodichloromethane	1	17
Bromoform	2	17
Bromomethane	1.2	34
Carbon disulfide	5	17
Carbon Tetrachloride	350	350
Carbon Tetrachloride	1.2	17
Chlorobenzene	2	17
Chloroethane	5.2	34
Chloroform	0.5	17
Chloromethane	0.8	34
Chlorotoluene	1	5
cis-1,2-Dichloroethene	1	5
cis-1,3-Dichloropropene	3.4	17
Dibromochloromethane	0.9	17
Dibromomethane	2	5
Dichlorodifluoromethane	1.8	10
Ethylbenzene	2	17
Methylene chloride	10	70
Tetrachloroethene	0.3	17
Toluene	2	17
trans-1,2-Dichloroethene	1	5
trans-1,3-Dichloropropene	3.4	17
Trichloroethene	1.2	17
Trichlorofluoromethane	2	10

Table I-11b
Detection Limit Ranges for Site 5 RI Soil Samples
Fresno Air National Guard, Fresno, California

Parameter	Detection Limits (µg/kg) Min.	Max.
Vinyl acetate	10	34
Vinyl chloride	1.8	34
Xylenes (total)	1	17
TPHC-as diesel	10	20
Semivolatile Organics (CLP)		
1,2,4-Trichlorobenzene	10	2200
2,4,5-Trichlorophenol	50	11000
2,4,6-Trichlorophenol	10	2200
2,4-Dichlorophenol	10	2200
2,4-Dimethylphenol	10	2200
2,4-Dinitrophenol	50	11000
2,4-Dinitrotoluene	350	2200
2,6-Dinitrotoluene	10	2200
2-Chloronaphthalene	10	2200
2-Chlorophenol	10	2200
2-Methylnaphthalene	10	2200
2-Methylphenol	10	2200
2-Nitroaniline	50	11000
2-Nitrophenol	10	2200
3,3'-Dichlorobenzidine	20	4400
3-Nitroaniline	50	11000
4,6-Dinitro-2-methylphenol	50	11000
4-Bromophenylphenyl ether	10	2200
4-Chloro-3-methylphenol	10	2200
4-Chloroaniline	10	2200
4-Chlorophenylphenyl ether	10	2200
4-Methylphenol	10	2200
4-Nitroaniline	50	11000
4-Nitrophenol	50	11000
Acenaphthene	10	2200
Anthracene	10	2200
Benzo(a)anthracene	10	2200
Benzo(a)pyrene	10	2200
Benzo(b)fluoranthene	10	2200
Benzo(g,h,i)perylene	10	2200
Benzo(k)fluoranthene	10	2200
Benzoic acid	50	11000
Benzyl alcohol	10	2200
bis(2-Chloroethoxy)methane	10	2200
bis(2-Chloroethyl)ether	10	2200
bis(2-Chloroisopropyl)ether	10	2200
bis(2-Ethylhexyl)phthalate	10	2000
Butyl benzyl phthalate	10	2200
Chrysene	10	2200
Di-n-butyl phthalate	10	2200

Table I-11b
Detection Limit Ranges for Site 5 RI Soil Samples
Fresno Air National Guard, Fresno, California

(Page 3 of 3)

Parameter	Detection Limits (μg/kg) Min.	Max.
Di-n-octyl phthalate	10	2200
Dibenzo(a,h)anthracene	10	2200
Dibenzofuran	10	2200
Diethyl phthalate	10	2200
Dimethyl phthalate	10	2200
Fluoranthene	10	2200
Fluorene	10	2200
Hexachlorobenzene	10	2200
Hexachlorobutadiene	10	2200
Hexachlorocyclopentadiene	10	2200
Hexachloroethane	10	2200
Indeno(1,2,3-cd)pyrene	10	2200
Isophorone	10	2200
N-Nitroso-di-n-propylamine	10	2200
N-Nitrosodiphenylamine	10	2200
Naphthalene	10	2200
Nitrobenzene	10	2200
Pentachlorophenol	50	11000
Phenanthrene	10	2200
Phenol	10	2200
Pyrene	10	2200

Table I-11c
Detection Limit Ranges for Site 5 SI Shallow Soil Samples
Fresno Air National Guard, Fresno, California

Parameter	Detection Limits (µg/kg) Min.	Max.
Volatile Organics (CLP)		
1,1,1-Trichloroethane	5	6
1,1,2,2-Tetrachloroethane	5	6
1,1,2-Trichloroethane	5	6
1,1-Dichlorethane	5	6
1,1-Dichloroethene	5	6
1,2-Dichloroethane	5	6
1,2-Dichloroethene (total)	5	6
1,2-Dichloropropane	5	6
2-Butanone	11	13
2-Hexanone	11	13
4-Methyl-2-pentanone	12	13
Acetone	8	39
Benzene	5	6
Bromodichloromethane	5	6
Bromoform	5	6
Bromomethane	11	13
Carbon disulfide	5	6
Carbon Tetrachloride	5	6
Chlorobenzene	5	6
Chloroethane	11	13
Chloroform	5	6
Chloromethane	12	13
cis-1,3-Dichloropropene	5	6
Dibromochloromethane	5	6
Ethylbenzene	5	17
Methylene chloride	5	21
Tetrachloroethene	5	6
Toluene	5	6
trans-1,3-Dichloropropene	5	6
Trichloroethene	5	6
Vinyl acetate	11	13
Vinyl chloride	11	13
Xylenes (total)	5	6
TPHC-as diesel	10	10
Semivolatile Organics (CLP)		
1,2,4-Trichlorobenzene	370	420
1,2-Dichlorobenzene	370	420
1,3-Dichlorobenzene	370	420
1,4-Dichlorobenzene	370	420
2,4,5-Trichlorophenol	1800	2000
2,4,6-Trichlorophenol	370	420
2,4-Dichlorophenol	370	420
2,4-Dimethylphenol	370	400

Table I-11c
Detection Limit Ranges for Site 5 SI Shallow Soil Samples
Fresno Air National Guard, Fresno, California

Parameter	Detection Limits (µg/kg) Min.	Max.
2,4-Dinitrophenol	1800	2000
2,4-Dinitrotoluene	370	420
2,6-Dinitrotoluene	370	420
2-Chloronaphthalene	370	390
2-Chlorophenol	370	420
2-Methylnaphthalene	370	420
2-Methylphenol	370	420
2-Nitroaniline	1800	2000
2-Nitrophenol	370	420
3,3'-Dichlorobenzidine	750	840
3-Nitroaniline	1800	2000
4,6-Dinitro-2-methylphenol	1800	2000
4-Bromophenylphenyl ether	370	420
4-Chloro-3-methylphenol	370	420
4-Chloroaniline	370	420
4-Chlorophenylphenyl ether	370	420
4-Methylphenol	370	420
4-Nitroaniline	1900	2000
4-Nitrophenol	1800	2000
Acenaphthene	370	420
Anthracene	370	420
Benzo(a)anthracene	370	420
Benzo(a)pyrene	370	420
Benzo(b)fluoranthene	370	400
Benzo(g,h,i)perylene	370	420
Benzo(k)fluoranthene	370	420
Benzoic acid	1800	2000
Benzyl alcohol	370	420
Bis(2-chloroethoxy)methane	370	420
Bis(2-chloroethyl)ether	370	420
bis(2-Chloroisopropyl)ether	370	420
bis(2-Ethylhexyl)phthalate	380	400
Butyl benzyl phthalate	370	420
Chrysene	370	420
Di-n-butyl phthalate	370	420
Di-n-octyl phthalate	370	420
Dibenzo(a,h)anthracene	370	420
Dibenzofuran	380	420
Diethyl phthalate	370	400
Dimethyl phthalate	370	420
Fluoranthene	370	420
Fluorene	370	420
Hexachlorobenzene	370	420
Hexachlorobutadiene	370	400
Hexachlorocyclopentadiene	370	420
Hexachloroethane	370	420

Table I-11c
Detection Limit Ranges for Site 5 SI Shallow Soil Samples
Fresno Air National Guard, Fresno, California

Parameter	Detection Limits (µg/kg) Min.	Max.
Indeno(1,2,3-cd)pyrene	370	420
Isophorone	370	420
N-Nitroso-di-n-propylamine	370	420
N-Nitrosodiphenylamine	370	420
Naphthalene	370	420
Nitrobenzene	370	420
Pentachlorophenol	1800	2000
Phenanthrene	370	420
Phenol	370	400
Pyrene	50	400
Styrene	5	6
Pesticides/PCBs (CLP)		
4,4'-DDE	18	20
4,4'-DDT	18	20
Aldrin	9.1	10
Alpha-BHC	9.1	10
Alpha-Chlordane	91	100
Arochlor-1016	91	100
Arochlor-1221	91	100
Arochlor-1232	91	100
Arochlor-1242	91	100
Arochlor-1248	91	100
Arochlor-1254	180	200
Arochlor-1260	180	200
Beta-BHC	9.1	10
Delta-BHC	9.1	10
Dieldrin	18	20
Endosulfan I	9.1	10
Endosulfan II	18	20
Endosulfan sulfate	16	19
Endrin	18	20
Endrin ketone	18	20
Gamma-BHC (Lindane)	9.1	10
Gamma-Chlordane	91	100
Heptachlor	9.3	10
Heptachlor epoxide	9.1	10
Methoxychlor	91	100
Toxaphene	180	200

APPENDIX J

BASELINE RISK ASSESSMENT

Baseline Risk Assessment for the 144th Fighter Wing California Air National Guard Fresno Air Terminal, Fresno, California

Submitted To:

Air National Guard Readiness Center
Andrews Air Force Base, Maryland

Prepared By:

IT Corporation
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Submitted By:

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Lockheed Martin Energy Systems, Inc.
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Prepared For:

U.S. Department of Energy
Contract DE-AC05-84OR21400

March 1997

KN/3069/APJ/3069APJ.COV/03-31-97(10:34am)/F2/NE

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List of Acronyms

ANG	Air National Guard
AVGAS	aviation gas/fuel
Base	Fresno Air National Guard Base
BCP	Base Collection Pond
BTEX	benzene, toluene, ethyl benzene, and xylene
BUN	blood urea nitrogen
CalEPA	California Environmental Protection Agency
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
cm	centimeter(s)
CNS	central nervous system
COC(s)	chemical(s) of concern
COPC	chemical(s) of potential concern
CRQL	Contract Required Quantitation Limit
CT	Central Tendency
d	day
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FAT	Fresno Air Terminal
FS	Feasibility Study
ft	foot; feet
FTA	Fire Training Area
g	gram(s)
GAF	gastrointestinal absorption factor
GC	gas chromatograph
GC/MS	Gas Chromatography/Mass Spectroscopy
HAZWRAP	Hazardous Waste Remedial Action Plan
HEAST	health effects assessment summary table
HI	hazard index
HQ	hazard quotient
hr	hour(s)
ICP	Inductively Coupled Plasma

IRIS	integrated risk information system
IT	IT Corporation
Kg	kilogram(s)
L	liter
LAAM BN	Light Anti-aircraft Mobilization Battalion
LOAEL	low-observed-adverse-effect-level
m	meter(s)
mg	milligram(s)
MS	mass spectroscopy
NOAEL	no-observed-adverse-effect-level
NOEL	no-observed-effect-level
PAHs	polyaromatic hydrocarbons; polycyclic aromatic hydrocarbon
PC	permeability coefficient
PCB(s)	polychlorinated biphenyl(s)
PCE	petrachloroethene
POL	Petroleum, Oil, and Lubricant
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD(s)	reference dose(s)
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
s	second(s)
SAP	sampling and analysis plan
SF(s)	cancer slope factor
SI	Site Investigation
SQL	sample quantitation limit
TCE	trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TPH	total petroleum hydrocarbons
µg	micrograms

UCL	95% Upper Confidence Limit on the Mean
USGS	U.S. Geological Survey
USMC	U.S. Marine Corp
VOC(s)	volatile organic chemical(s)
yr	year(s)

J.1.0 Introduction

The baseline risk at the site is the risk to human receptors (real or hypothetical) that may occur under various scenarios if no remedial actions are taken to reduce the extent of present environmental pollution or potential exposure. This baseline risk assessment follows the methodology given in the Risk Assessment Work Plan (IT, 1993a) and follows the guidance outlined in the Risk Assessment Guidance for Superfund (EPA, 1989a); California Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities (CalEPA, 1992); California Guidance for Ecological Risk Assessment of Hazardous Waste Sites and Permitted Facilities (CalEPA 1994a and 1994b); and subsequent agency guidance.

J.1.1 Objectives

The objectives of this baseline risk assessment are to:

- Characterize the chemical sources and determine chemicals of potential concern (COPC) a site present within the California Air National Guard (ANG) Base in Fresno, California.

- Evaluate transport of chemicals from the source to potential exposure points.

- Identify potential receptors and quantify potential exposures under current and future conditions.

- Characterize the potential baseline risks associated with the ANG area under current and future conditions.

The results of the baseline risk assessment provide the basis for determining whether or not remedial action is necessary, and the justification for performing any remedial actions at a site.

J.1.2 Organization

A human health risk assessment, as defined by U.S. Environmental Protection Agency (EPA) (1989a), is organized about the following steps:

- ***Site Characterization.*** Data regarding site geography, geology, hydrogeology, climate, and demographics of populations in the area are evaluated.

- ***Data Collection.*** Samples of environmental media, including background samples, are collected and analyzed.

- ***Data Evaluation.*** The analytical data are analyzed statistically to identify the nature and extent of contamination, and to identify COPC.

- ***Exposure Assessment.*** Potential receptors are identified under current and future conditions, potential exposure pathways are identified, exposure point concentrations and chemical intakes are quantified.

- ***Toxicity Assessment.*** Qualitative and quantitative toxicity data for the COPC are evaluated, and toxicity values [reference doses (RfDs) for noncancer effects; cancer slope factors (SFs) for carcinogenic effects] are located or derived.

- ***Risk Characterization.*** The output of the exposure assessment and the toxicity assessment are combined to quantify the total noncancer and cancer risk to the hypothetical potential receptors.

- ***Uncertainty Analysis.*** Uncertainties in all phases of the risk assessment are identified, and their individual effects on the results of the risk assessment are discussed.

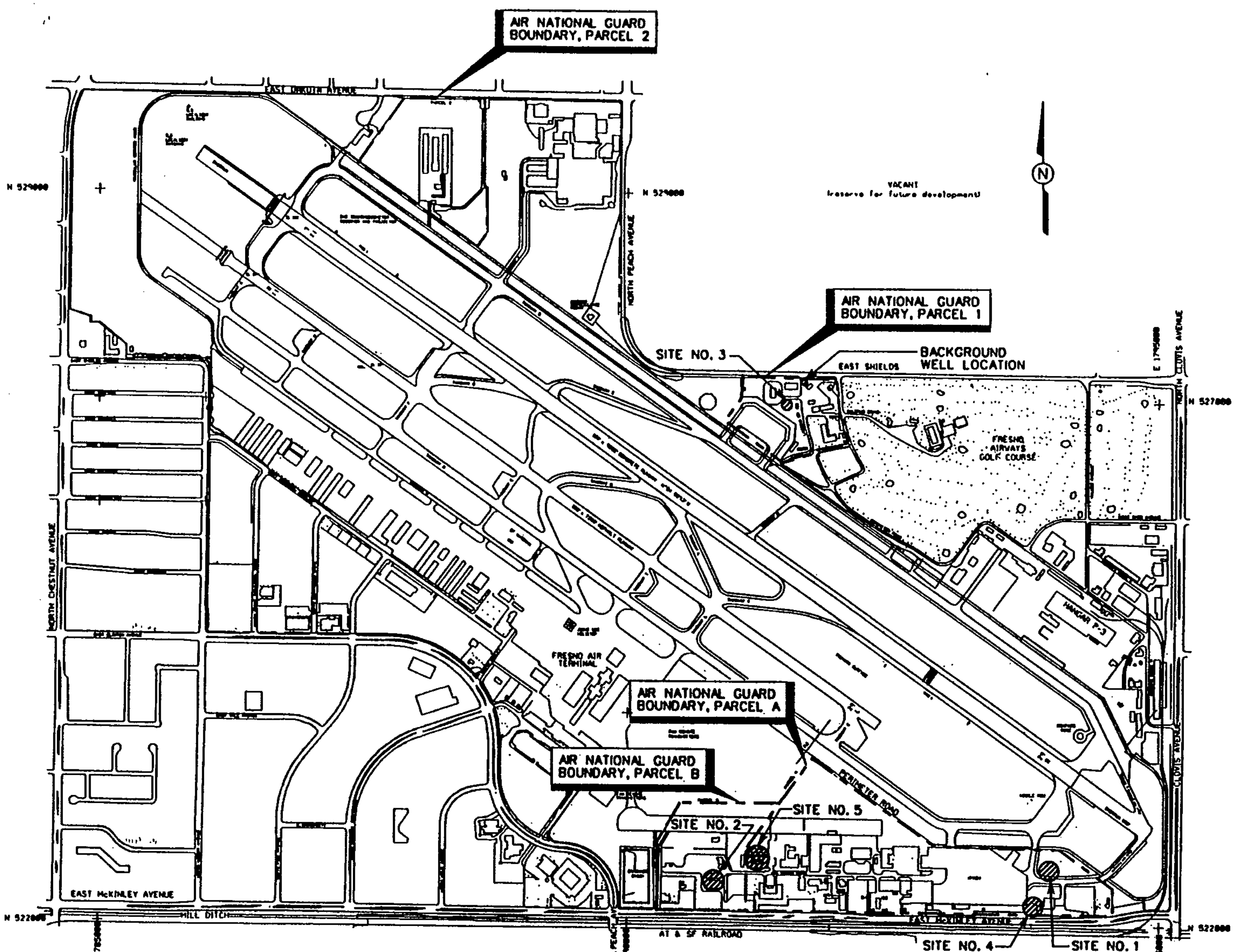
Data were initially collected and analyzed as part of the Site Investigation (IT, 1992a). Data from previous sampling have been supplemented by data from recent sampling as described in the Interim Report of Findings, Focused Remedial Investigation (IT, 1993b), and the Quarterly Groundwater Monitoring Report, April 1993 (IT, 1993c). Information from the deep aquifer investigation is not considered in this risk assessment because contaminants potentially related to operations associated with the Fresno ANG Base (Base) have not impacted this aquifer. This is discussed in detail in Section J.1.3.3, Hydrogeology.

J.1.3 Site Background

This section provides a brief description of the physical setting of the site and other pertinent background information, such as land use and hydrogeology, which will provide the reader with the necessary information to understand the assumptions and scenarios used in this risk assessment.

J.1.3.1 Physical Setting

The Fresno Air Terminal (FAT) is located within the San Joaquin Valley of the Central Valley of California. The terminal is within the city limits of Fresno with the City of Clovis approximately 4 miles north of the terminal. The FAT is base to the 144th Fighter Wing, California Air National Guard. The ANG leases approximately 140 acres of land from the City of Fresno on three different parcels inside the airport boundaries (Figure J-1).



LEGEND:

— - — PROPERTY BOUNDARY

SCALE

0 1000 2000 FEET

FIGURE J-1
BASE MAP LOCATION MAP OF
IDENTIFIED INVESTIGATION SITES

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL
TECHNOLOGY
CORPORATION

STARTING DATE: 11/20/95	DATE LAST REV.: 1/3/96	DRAFT. CHCK. BY: C.TUMLIN	INITIATOR: S.LOGAN	DWG. NO.:409724ES.042	
DRAWN BY: D.AGUILAR	DRAWN BY:D.BILLINGSLSEY	ENGR. CHCK. BY: S.LOGAN	PROJ. MGR.:D.BURTON	PROJ. NO.:409724	—

FILENAME409724ES.042 16:54:33 Jan. 3, 1996 DLB

Five sites were identified as potentially contaminated from past use and disposal practices of material and waste that subsequently have been characterized as hazardous. These sites are:

- Site 1 - Old Fire Training Area (FTA)
- Site 2 - Base petroleum, oil, and lubricant (POL) storage area
- Site 3 - Storage area at the U.S. Marine Corps (USMC) subleased area
- Site 4 - Suspect Burial Area
- Site 5 - Base Collection Pond (BCP)

Sites 1, 2, 4, and 5 are located in the main leased parcel, which is bordered on the south by McKinley Avenue. Site 3, located within the parcel bordered by East Shields Avenue and taxiway B, is subleased by the ANG to the USMC. Based on findings of the site investigation, Site 4, the Suspect Burial Area, was removed from any further investigation or risk-based activities because it was concluded that hazardous materials were not buried at this site and that further investigation was not required. Therefore, this site is not evaluated in this risk assessment.

Site 2 (POL storage area) is scheduled for closure under the California Leaking Underground Fuel Tank Program. This program has specific guidance for the derivation of remediation goals, and remediation of this site will meet or exceed those standards. Given that this site will be evaluated and remediated under a different program, it will not be evaluated in the Remedial Investigation (RI).

Sites 1 and 3 have been addressed in a supplemental Site Investigation (SI). In this study, concentrations of contaminants in soils were compared to EPA Region IX, risk-based screening concentrations for residential soils. These screening concentrations represent the maximum concentration of a constituent in soil that does not pose an unacceptable risk to human health. All of the concentrations at Sites 1 and 3 were below the respective screening level concentrations (IT, 1997). Based on this analysis, it was concluded that contamination at these sites does not present an unacceptable risk to human health. The earlier SI concluded that contaminants did not present a significant risk to ecological receptors (IT, 1992b). Therefore, these sites will not be addressed in this study.

Site 5-BCP will be quantitatively evaluated herein for potential risks associated with chemicals detected in soil and/or groundwater. In addition to Site 5-BCP, an evaluation of groundwater on a Base-wide scale will be conducted.

J.1.3.2 Land Use

The current mission of the ANG is to support the 144th Fighter Wing and host the U.S. Marine 4th Light Anti-aircraft Mobilization Battalion (LAAM BN) and the California Civil Air Patrol. The Base has approximately 400 full-time employees and the population increases to more than one thousand on weekends when monthly training takes place. The areas north, west, and south of the terminal are predominantly commercial and industrial, while the area east of the FAT is primarily agricultural. The existence of a large air terminal makes it unlikely that the Base will be used for any purpose not associated with either the ANG or the commercial operations associated with the FAT. Land uses adjacent to the FAT are generally more compatible to industrial uses than commercial or residential uses. It is unlikely that any residential developments will be built in the areas adjacent to the FAT (IT, 1992b).

J.1.3.3 Hydrogeology

This section provides a brief description of the hydrogeology of the Base. The reader is referred to Section 5.0 (Site-Specific Hydrology) for a more detailed discussion.

The geology beneath the Base from ground surface to the water table (80 feet bgs) is characterized by alluvial fan deposits that have been shown to be vertically and horizontally heterogenous. Specific beds are localized in extent. A hardpan layer is present near ground surface, at depths ranging from 4 to 7 feet bgs. Its presence and thickness across the Base varies; at places it is only 3 feet thick and in others, its extends to depths of 18 feet bgs.

Two distinct aquifers are present below the Base: the A aquifer, which is generally regarded as the water table aquifer, and the underlying B aquifer. Groundwater measurements of the water table aquifer show that groundwater flows predominantly from the northeast towards the southwest across the Base. Groundwater in both aquifers is considered to be potable.

The water table aquifer is approximately 120 to 130 feet thick, extending from 80 feet bgs to 200 to 210 feet bgs (245 feet elevation above mean sea level [msl] to 115 feet msl). The A and B aquifers are separated by a thick aquitard that is up to 65 feet thick, and consists of hard silt with little moisture. This aquitard forms the base of the A aquifer.

The upper A aquifer is divided into subunits based on the presence of several discontinuous aquitards within the A aquifer. However, none of the aquitards appear to be laterally continuous, indicating that at least partial hydraulic communication exists among the subunits. Based on

geologic and hydrogeologic interpretation, the A aquifer is divided into three subaquifers: A1, A2, and A3. However, their distinction is unclear and is subject to interpretation.

The A1 subaquifer ranges from 40 to 55 feet in thickness, from an elevation of 245 feet msl to 190 feet msl. Where it is distinguishable, the A2 subaquifer ranges in thickness from 20 to 45 feet, and the A3 subaquifer ranges from 15 to 35 feet in thickness. The thickness of the underlying B aquifer has not been determined.

The three subaquifers are believed to be in at least partial communication due to the discontinuity of the aquitards. Aquifers include sand, silty sand, and silt, with the finer-grained lithologies yielding water in greater quantities than would normally be expected. A repetitive sequence of coarse- and fine-grained sediment, approximately 100 feet thick, forms an interconnected sequence of aquifer and aquitard material that is divided into the A1, A2, and A3 subaquifers. Continuous sand layers are present, forming pathways for lateral groundwater flow and potential contaminant migration. Consolidated fine-grained aquitards within the larger silt units form potential barriers to vertical flow. In some cases coarser-grained lithologies are included as aquitard material. A detailed description of this aquifer is given in Section 5.3.2.

During more recent investigations at the Base, monitoring wells have been installed into different levels of the A aquifer. Water table wells are screened across the first occurrence of groundwater; these wells penetrate the first 10 to 15 feet of the A1 subaquifer. Four monitoring wells have been installed near the bottom of the A1 subaquifer. These wells have a screen length of 10 feet and were assigned a monitoring well label with a suffix "B". Four other monitoring wells have been installed into the A2 subaquifer; these were assigned a monitoring well label with a suffix of "C". No monitoring wells have been installed into the A3 subaquifer or the B aquifer as part of any investigation programs associated with the ANG.

Contaminants detected in the deeper well series (deeper A1 zone, or "B" wells, and A2 zone, or "C" wells) are similar to those found in the shallow A1 zone. The primary contaminant that can be directly attributable to the Base, tetrachloroethene (PCE), was only detected in wells installed in the A1 subaquifer. Groundwater sampling data show that PCE has not migrated to the A2 or deeper aquifer regions, as described in Section 6.4.2 of the RI Report.

This baseline risk assessment will focus on quantifying risk from exposure to groundwater from the A1 zone, since this is where the highest concentrations of PCE were detected. Groundwater in the A2, A3, and deep B aquifer is impacted by trichloroethene which has been shown to not be

primarily associated with the Base. Additional investigations are being performed by other contractors to determine the depth and lateral extent of shallow and deep groundwater contamination on a more regional scale. Risk estimates from exposure to deep groundwater are therefore more meaningful in a regional contamination setting and no risk estimates associated with deeper groundwater will be included in this baseline risk assessment.

J.2.0 Identification of Chemicals of Potential Concern

When performing a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) baseline risk assessment, data for environmental media are evaluated to determine potential site-related contaminants and exposures for each medium (EPA, 1989a). The ANG area is divided into several smaller sites of investigation. Baseline risk assessments are prepared separately for each site.

J.2.1 Data Sources

Data for the ANG area have been gathered as part of the SI activities conducted by IT Corporation between July 1990 and April 1993 (IT, 1992b, 1993b, and 1993c). Data were collected to accomplish the following objectives:

- Identify the specific chemical contaminants present and their concentrations in soil and groundwater
- Evaluate the site hydrogeology, chemical migration pathways, and specifics of groundwater movement that influence chemical migration
- Evaluate receptors for potential exposure to migrating contamination
- Quantify the risks associated with potential exposure to chemicals.

Soil and groundwater samples for laboratory analyses have been collected from Site 5-BCP, and additional groundwater samples have been collected from groundwater monitoring wells located along the Base property boundary. Subsurface soil samples at Site 5-BCP were also screened for volatile organic compounds (VOC) with a portable gas chromatograph (GC) in a field laboratory setting. Field GC results were used to select those soil samples to be shipped to a fixed-base laboratory for confirmation analysis. In addition to the site-specific monitoring wells, several others have been installed across the western portion of the Base along the Base property line to determine groundwater quality entering and leaving Base property. Wells were installed hydraulically upgradient, downgradient and lateral gradient and are shown in Figure J-2 (wells labeled with a "MWBP-" prefix). Soil samples for chemical analysis were not collected while drilling these wells. Tables J-2-1 and J-2-2 provides a summary of the number of samples collected at each site and their analytical parameters. Sample results for all fixed-base analytical testing are included in Appendix I of the RI Report. Field screening data for Site 5-BCP are found in Appendix A of the RI Report.

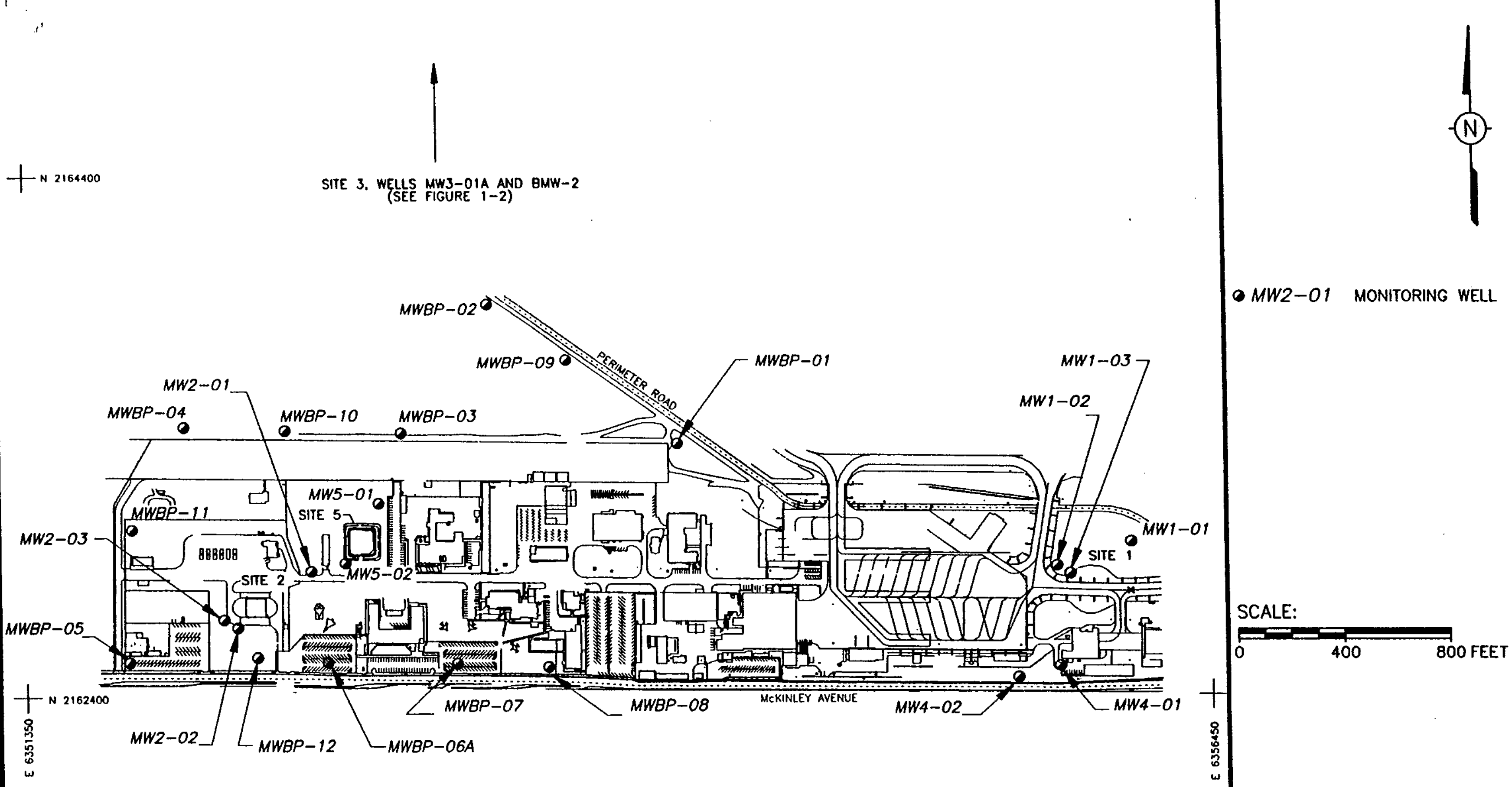


FIGURE J-2
SITE AND MONITORING WELL LOCATIONS, MAIN BASE PROPERTY

CALIFORNIA AIR NATIONAL GUARD
FRESNO AIR TERMINAL
FRESNO, CALIFORNIA

INTERNATIONAL TECHNOLOGY CORPORATION

STARTING DATE: 10/16/95	DATE LAST REV.:	DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: S. LOGAN	DWG. NO.: 409724-B-106
DRAWN BY: D. BILLINGSLEY	DRAWN BY:	ENGR. CHCK. BY: S. LOGAN	PROJ. MGR.: D. BURTON	PROJ. NO.: 409724

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J.2.2 Data Validation

Data validation is an after-the-fact, independent, systematic process of evaluating data and comparing them to pre-established criteria to confirm that the data are of the technical quality necessary to support the decisions made in the RI/Feasibility Study (FS) process. Specific characteristics associated with the data are reviewed to determine whether the data meets the stipulated data quality objectives. The quality objectives address five principal requirements:

- Precision
- Accuracy
- Completeness
- Comparability
- Representativeness.

To verify that these objectives are met, field measurements, sampling and handling procedures, laboratory analysis and reporting, and nonconformances and discrepancies in the data are examined to determine compliance with appropriate and applicable procedures. The procedures and criteria for validation are defined in the RI/FS Data Validation Program Guidelines, which are based on the EPA national functional guidelines for data review (EPA, 1988a).

The validation process for the ANG RI was divided into two phases. The first phase considered field data to verify the completeness, accuracy and representativeness of field sampling. The second phase dealt with laboratory procedures for chemical analyses. The key field data reviewed in the validation process are:

- Field Activity Daily Logs
- Sample Collection Logs
- Specific field forms for sample collection and handling
- Analysis Request and Chain of Custody Record
- Field instrument calibrations
- Field personnel training
- Variances and surveillances of field activities.

The key analytical data reviewed in the validation process are those contract laboratory program (CLP) or "CLP-like" methods generated by the fixed-base laboratory and include an evaluation of the following:

- Organic chemicals
  - Holding times
  - GC/Mass Spectroscopy (MS) calibration
  - Surrogate recoveries

- Matrix spike, matrix spike duplicates
- Blank evaluation using the 5X/10X rule
- Internal standards.

- Inorganic chemicals
  - Holding times and preservation
  - Inductively Coupled Plasma (ICP), Graphite Furnace and Cold Vapor Atomic Analysis instrument performance checks
  - Initial and continuing calibrations
  - Blank evaluations
  - Matrix spike evaluations
  - ICP serial dilution and interference checks
  - Laboratory control sample checks
  - Duplicate sample analysis
  - Furnace atomic absorption checks.

The culmination of the validation process was the assignment of the qualifier flag for each analyte defining the confidence level in the data. The measured chemical concentration data obtained in the sampling program for the Base have been validated and have been through a peer review process, as stated in the addendum to the Site Investigation Sampling and Analysis Plan (SAP) (IT, 1992a). Data that did not meet criteria addressed during data validation were flagged with an "R" qualifier, which meant that the data were to be rejected. These data are not used in the quantitative baseline risk assessment process. Data flagged with the "J" qualifier, meaning the values are "estimated," are used in the quantitative baseline risk assessment, consistent with EPA guidance (EPA, 1989a). Validation qualifiers are described further in the following section.

J.2.2.1 Site-Related Data

All environmental sampling data were evaluated for suitability for use in the quantitative baseline risk assessment. Data obtained from the following analytical methods are generally not considered appropriate for quantitative baseline risk assessment:

- Analytical methods that are not specific for a particular chemical, such as total organic carbon or total organic halogen;
- Field screening instruments such as HNus and organic vapor analyzers.

Field screening data for VOCs at Site 5-BCP, however, were used in the quantitative baseline risk assessment. Soil samples for the screening analysis versus the fixed-base laboratory analysis for VOCs do not agree. Though prescribed sample preservation techniques are followed and analyses are performed within holding times for samples shipped to a fixed-base laboratory, significant losses of VOCs can occur. Mechanisms responsible for the losses include volatilization, biodegradation, and chemical transformation. This appears to be the case for the discrepancy observed from the two sets of data; therefore, data provided from the field GC are considered to be more indicative of subsurface conditions at Site 5-BCP. A sample that is analyzed soon and with little disruption, such as one collected for field screening analysis, is more likely to be representative of actual site conditions (Siegrist, 1993).

Field screening data are obtained using the same analytical procedures as a fixed-base laboratory analysis. However, field screening data are analyzed using Hazardous Waste Remedial Action Plan (HAZWRAP) Quality Control (QC) Level B as compared to QC Level C for fixed-base laboratories. Therefore, there exists a greater chance of contamination occurring in a field laboratory, and the data are not as carefully reviewed as Level C data. A description of the field screening analytical procedures is given in Appendix A of the "Focused Remedial Investigation Addendum to the Site Investigation Sampling and Analysis Plan" (IT, 1992a). Supplemental field laboratory information is available in Appendix A of the RI report.

Data from the Toxicity Characteristic Leaching Procedure (TCLP) were used to determine if soils at the ANG had the characteristics of Resource Conservation and Recovery Act (RCRA) hazardous waste; these data were not used for risk assessment.

All fixed-based laboratory data that were used in this RA were analytical results for chemicals that were reported using CLP data qualifiers. Chemicals flagged with a "U" qualifier were not detected, or detected at a concentration below the normal, random "noise" of the analytical instrument. Estimated quantitative results, such as those identified by a "J" qualifier, were used in the quantitative baseline risk assessment (EPA, 1989a). The "J" qualifier is the most encountered data qualifier in CLP data packages. Under the CLP, the "J" qualifier describes an estimated value when a compound is present (spectral identification criteria are met), but at values less than the Contract Required Quantitation Limit (CRQL) or when QC samples suggest that the sample results may be in error (e.g., when spike samples are outside of required limits or when holding times are slightly missed) (EPA, 1989a). If validation of the data determined that samples must be rejected (assigned an "R" qualifier), the data were not used for the quantitative baseline risk assessment. One example of "R" qualified data is data whose holding times have

exceeded the specified limits. Data generated using the field laboratory is not validated using this process. Therefore, all field data generated for Site 5-BCP soils were used in the risk assessment.

Positive hits for all chemicals in soil occurred sporadically at different depths in soil at different locations. Field duplicate samples were assumed to be discrete samples and were included in chemical data sets. According to EPA guidance (EPA, 1992a), when there is a limited amount of data or extreme variability in measured or modeled data, the calculated 95 percent upper confidence limit (UCL) on the mean can be higher than the highest measured or modeled concentration. In such cases, the highest measured or modeled concentration can be used instead of the UCL as the source-term concentration. The highest detected concentrations in soil (both fixed-base laboratory results and field screening data at Site 5-BCP) were, therefore, used as source-term concentrations for reasonable maximum exposure (RME) risk calculations for that particular chemical in soils. Since the data tended to be scattered over a wide range of depths in soil, the maximum detected concentration from the entire depth of sampling were used for leachate modeling.

For groundwater, although up to six rounds of sampling were conducted in some monitoring wells, positive hits were infrequent for most chemicals. The same EPA guidance (EPA, 1992a) was applied whereby the maximum measured concentration was chosen over the UCL as the source-term concentration because data for most chemicals were limited. Rather than assume half the sample quantitation limit for nondetected values of chemicals with at least a single positive hit and compile data sets for statistical calculations (this would have the effect of lowering the calculated value for the UCL), a more conservative approach of using maximum detected concentrations as source-term concentrations was adopted and applied consistently for all groundwater risk calculations.

Calculations for a central tendency receptor were made for selected exposure scenarios, which had shown an adverse health impact for the RME. The central tendency receptor is defined as the receptor whose exposure is calculated with average or central tendency values of exposure variables. The central tendency calculations were expected to give more reasonable exposure estimates. Due to insufficient datasets for the calculation of UCL concentrations, the maximum measured concentrations were also used as source-term concentrations for central tendency calculations.

J.2.2.2 Background Data

There is one background soil boring (SBB1) for the entire Base from which soil samples were taken from several depth intervals. There are two background monitoring wells (BMW-1 and BMW-2) for the entire Base. Soil boring SBB1 was part of the drilling for the construction of BMW-1, which has been abandoned. The background wells are located near Site 3, just south of East Shields Avenue. Several monitoring wells were installed along the Base property boundaries across the western portion of the Base (Figure J-2). Six "Base Perimeter" wells (MWBP-01 through -04, MWBP-09 and MWBP-10) were installed along the upgradient Base boundary. Analytical results from these locally upgradient wells can be compared to site-specific groundwater at Site 5-BCP to assist in determining site-related COPC.

J.2.3 Selecting Chemicals of Potential Concern

COPC were selected for soils at Site 5-BCP and groundwater underlying Site 5-BCP and upgradient and downgradient of the Base. The criteria used for the selection of COPC is described below.

J.2.3.1 Comparison of Site-Related Data to Background Data

Background soil samples collected at the Base were analyzed for volatile and semivolatile organic chemicals, pesticides, and polychlorinated biphenyls (PCBs), RCRA metals, and organic lead. Site-specific background ranges for inorganic were established based on samples collected from boring SBB1. Soil boring SBB1 was completed at a location northeast of Site 3 to provide background information on soils in the site and vicinity of the Base. This boring was sampled using a California-type split-spoon sampler at approximately 10-foot intervals. A total of ten samples (which include two duplicate samples) were collected from SBB1, which was drilled to a depth of 66.5 feet. A detailed discussion of the results is given in Section 3.3.1 of the SI report (IT, 1992b).

Metals were not analyzed in soil samples from Site 5-BCP because metals are not likely to be COPC. No organic compounds were detected in background soils; therefore, none of the organic COPC in soils were eliminated based on this screening.

Base-wide background groundwater samples from wells BMW-1 and BMW-2 were analyzed for benzene, toluene, ethyl benzene, and xylene (BTEX), total petroleum hydrocarbon (TPH as diesel), VOCs, semivolatiles, pesticides/PCBs, and metals. Metals analyses did not yield any positive detections except for zinc at 24.7 µg/L. All other metals were either not detected or

detected at estimated concentrations (J qualified values). Two semivolatile organics, bis(2-ethylhexyl)phthalate and chrysene, were detected at an estimated concentration of 5 μg/L in well BMW-1 during one round of sampling. All other organics tested were below detection limits.

Organic analyses were performed for groundwater samples at Site 5-BCP, and at upgradient and downgradient monitoring wells located along the Base perimeter. Organic compounds were detected at Site 5-BCP and in the Base perimeter wells. Groundwater along the northern Base boundary (i.e., upgradient perimeter wells) contains chlorinated organics, indicating an upgradient, off-site source of contamination. An area-specific background range has been compiled, showing the presence of off-site contamination (Section 6.1, Table 6-1), to determine the impact to groundwater from the Base. Because several of the reported compounds detected at Site 5-BCP are present in upgradient groundwater, they are not considered to be associated with Base facilities. The following VOC is not considered to be related to past ANG activities at Site 5-BCP because they are present in elevated concentrations in the upgradient groundwater and are not present in significant concentrations in Site 5-BCP soils: carbon tetrachloride, 1,2-dichloropropane, and trichloroethene (TCE).

Low concentrations of TCE were detected in soil screening samples at Site 5-BCP. It cannot, therefore, be stated that TCE was never introduced to groundwater through Site 5-BCP. As previously discussed in Section 6.2.2.2 of the RI report, the concentrations present in soils would not account for the concentrations of TCE detected in the downgradient perimeter monitoring wells. The data show that TCE concentrations downgradient are well below upgradient concentrations. In addition, analysis of data (Figure 6-1) shows a trend of decreasing TCE concentrations around Site 5-BCP. This phenomenon is likely due to dilution effects from infiltrating water, which does not have significant concentrations of TCE, diluting the TCE plume coming on site from the upgradient source. In addition, TCE was not detected in the closest downgradient well to Site 5-BCP, MW5-02 (Table 6-5). Because TCE is present in upgradient groundwater and because TCE was not detected in well MW5-02, TCE in groundwater is not considered to be currently related to Site 5-BCP.

J.2.3.2 Other Criteria for Selecting Site-Related Chemicals of Potential Concern

Other criteria were applied to determine or eliminate COPC. An organic chemical was not identified as a COPC if it was a common laboratory contaminant and all sample concentrations were less than ten times the highest associated blank (i.e., trip blank, field blank, laboratory blank, or equipment rinsate) concentration (EPA, 1989a). Common laboratory contaminants include acetone, 2-butanone, methylene chloride, toluene, and phthalate esters. Other organic

chemicals were eliminated if all results were less than five times the highest concentration detected in a blank, such as a laboratory blank, field blank, trip blank, or equipment rinsate blank (EPA, 1989a).

J.2.4 Chemicals of Potential Concern

Based on sampling results, a COPC list for each environmental medium tested at the Base was developed. Each chemical found in soils and groundwater with at least one positive result (i.e., quantitative value above the method detection limit) was included in the COPC list. Chemicals found during the sampling effort were subsequently eliminated from the COPC list based on the following factors:

- If the chemical was detected only once in the environmental medium and is a common laboratory contaminant (i.e., acetone, methylene chloride, 2-butanone, and phthalates)
- If a chemical was detected once and the concentration is not detected in a duplicate sample
- If a chemical was detected once and the concentration is an estimated value that is below the detection limit.

These criteria were used to identify chemicals which are unlikely to be site-related contaminants based on their low detection rate. The EPA guidance for Superfund (EPA, 1989a) states that contaminants may be eliminated as COPC if they are detected in less than 5 percent of the samples. A single detection of an organic in the soil samples is less than 2.5 percent of the soil samples. The first two criteria are used to identify contaminants that are likely to be the result of sampling/laboratory contamination. The third criterion is used if a chemical appears in only one sample at a concentration below the detection limits (i.e., the concentration was estimated). In this case, it is assumed that the chemical is not prevalent at the site or is an artifact and should not be considered a site-related chemical.

Analytical data for the soils and groundwater are compiled and evaluated to identify COPC and estimate source concentrations for each chemical in each medium. Table J-2-3 lists the COPC for Site 5-BCP, as well as the Base perimeter upgradient and downgradient wells and the reasoning for deletion of selected chemicals as COPC.

J.3.0 Exposure Assessment

The objective of the exposure assessment is to determine the magnitude of exposure that a potential receptor may have with site-related COPC. A conceptual site model is an invaluable tool in determining exposure. Exposure assessment involves three stages:

- Identification of COPC release and migration pathways

- Identification of the potential receptors, under various land use or site condition scenarios, and the pathways by which the receptor might be exposed

- Quantification of intakes, or contact rates, of COPC.

J.3.1 Conceptual Site Model

A conceptual site model (Figure J-3) is developed to provide the basis for identifying and evaluating the potential risks to human health in the baseline risk assessment. By illustrating every possible pathway by which a potential receptor may be exposed, including all sources, release and transport pathways, and exposure pathways, the conceptual site model facilitates consistent and comprehensive evaluation of risk to human health, and helps to ensure that potential pathways are not overlooked. The elements necessary to construct a complete exposure pathway and develop the conceptual model include:

- Source of contamination (i.e., contaminated environmental media)
- Contaminant release mechanisms
- Contaminant transport pathways
- Receptors
- Exposure pathways.

J.3.1.1 Sources of Contamination

Soil and groundwater in the Base area have shown signs of contamination from past disposal practices. The Site 5-BCP was until recently a collection sump that received washdown waters and storm runoff from drain gutters across the western portion of the Base. Site 5-BCP covered an area of approximately 19,000 square feet and had steeply sloping sides to the bottom, which was about 12 feet below bgs. In 1995, Site 5-BCP was filled to grade with clean soil to prepare for its conversion into an above ground fuel storage area for the Base. This work was approved by the State of California. Thus, the collection pond no longer exists as it did during the previous investigations. Samples were been collected from soil and groundwater at Site 5-BCP prior to construction activities.

Contaminants from sources outside the Base are contributing to groundwater contamination. Upgradient groundwater monitoring wells located along the perimeter of the Base show that carbon tetrachloride, 1,2-dichloropropane, diethyl phthalate, di-n-butyl phthalate, and trichloroethene are migrating on site from sources upgradient of the Base.

J.3.1.2 Contaminant Release Mechanisms and Transport Pathways

Once released to the environment, COPC may exist in or travel to media to which the receptors may be exposed. Contaminants in soils at Site 5-BCP are now at a minimum of 12 feet bgs. Therefore, transport of constituents via wind erosion (i.e., fugitive dust) or surface water runoff are not viable migration pathways. Potential release mechanisms include volatilization into the atmosphere and leaching into groundwater.

Volatilization is limited to those contaminants which have high vapor pressures and are located relatively close to the surface. The presence of an impermeable surface such as asphalt (which is planned in the future for Site 5-BCP) would significantly reduce, or likely eliminate, the potential release of contaminants. Chemicals likely to volatilize from soils include: acetone, cis- and trans-1,2-dichloroethene, methylene chloride, tetrachloroethene, and trichloroethene.

TPH is a measure of the various organic components of a specific fuel. At Site 5-BCP, the TPH was measured as diesel fuel. Diesel fuels are complex mixtures of middle distillates consisting of less volatile (C_9-C_{20}) hydrocarbons from the distillation of crude oil (IARC, 1989a; EPA, 1992b). They may contain hundreds of individual hydrocarbon compounds, which leave the distillation column at 150-360°C, as well as additives. The actual composition may vary, depending on sources of crude oil, the refinery processes used, and the product specifications. Given that diesel fuel is primarily composed of compounds with boiling points above 150°C, volatilization is not likely to be a viable migration pathway.

Migration of soil contaminants to groundwater could occur from infiltration and percolation of rainwater through the soil. The extent of contaminant migration depends primarily on the amount of rainfall, evaporation, solubility of the chemical in water, the chemical partitioning coefficient, and distance to the water table, which is approximately 80 feet bgs. In general, VOCs travel more easily through soils than semivolatile organics (like high-boiling fuel hydrocarbons). Once in groundwater, contaminants may be transported vertically and laterally with groundwater flow.

The primary contaminant that can be directly attributable to the Base, PCE, was only detected in wells installed in the A1 subaquifer. Groundwater sampling data show that PCE has not migrated to the A2, or deeper, aquifer regions, as described in Section 6.4.2 of the RI Report. Therefore, contaminants associated directly with the Base have not migrated into the deeper aquifers on site. It should be noted that groundwater in the deeper aquifers has been contaminated with chemicals associated with activities upgradient of the Base. Additional investigations are being performed by other contractors to determine the depth and lateral extent of shallow and deep groundwater contamination on a more regional scale.

Off-site migration is likely to occur as a result of lateral migration. The ANG area is predominantly industrial in nature, and it is very unlikely that there would be exposure to contaminants in groundwater underlying the Base as a result of additional groundwater wells being placed on Base property for residential or agricultural use. Future land-use plans also indicate that the ANG area will remain industrial in nature, surrounded predominantly by commercial/industrial areas. Based on these plans, the transport pathways to be evaluated will be groundwater transport of contaminants to the Base boundary.

J.3.1.3 Potential Receptors and Exposure Pathways

Based on the existing and predicted land-use conditions at the ANG and surrounding areas, the only likely exposure would be to on-site construction workers, Base personnel, and off-site residents using drinking water wells. The ANG area is predominantly industrial in nature. Future land-use plans also indicate that the ANG area will remain industrial in nature, surrounded predominantly by commercial/industrial areas. It is unlikely that the Base will be used for residential or agricultural purposes. Therefore on site receptors will be represented by construction workers and Base personnel.

The collection pond at Site 5-BCP has been filled in, graded and covered with approximately 12 feet of fill material; thus, there is no direct exposure to contaminated soils. California guidance states that construction workers may be exposed to contaminants in soils to depths of 10 feet bgs (CalEPA, 1992). Given that contamination at Site 5-BCP is below this depth, exposure of construction workers would be limited to exposure via inhalation of volatiles.

The area is currently scheduled to be an open POL area, i.e. there will be no structures built on the site, and Base personnel working the site will be in the open. In the future, the specific land use at the site may change and a structure may be built on the site. Base personnel may be

exposed to volatiles released into the atmosphere (current or near-future scenario) or they may be exposed to volatiles released into a building (future scenario).

The area downgradient of the Base is predominantly residential and industrial. The City of Fresno uses groundwater as its source of drinking water (City of Fresno, 1990). There are no agricultural wells located in the downgradient areas near the Base (City of Fresno, 1990). Given the amount of development in this area, agricultural land use is unlikely. Therefore, exposure resulting from the use of groundwater for irrigation of agricultural fields is unlikely. Off-site receptors would include only residents using a drinking water well within the contaminated areas downgradient of the Base (Figure J-2). Exposure pathways for residential use of groundwater include ingestion, dermal contact while showering, and inhalation of volatiles while bathing, washing and other household activities.

J.3.2 Exposure Point Concentrations

Exposure to contaminants in groundwater were evaluated under current and possible future conditions. Current or near-future exposures were evaluated using measured concentrations in groundwater. As a conservative assumption and due to the lack of a statistically significant number of samples, the maximum concentrations detected in groundwater were used as the exposure concentrations. For potential future exposures, leaching of contaminants into groundwater was modeled.

As previously discussed, receptors are not likely to come in direct contact with contaminated soils at Site 5-BCP. However, contaminated soils are a source term where contaminants that are present may be released to groundwater and migrate to exposure points, and where human receptors may come in contact with contaminants. Environmental fate and transport models are used to determine potential exposure concentrations. Base on the source-term concentration, these models use site-specific data to estimate the potential concentration in environmental media at the point of exposure.

Source Term Concentrations. COPC have been identified in soil and groundwater at the ANG. The detection of contaminants in soils was sporadic. Depths of detected concentrations in borings varied. The contamination appears to be limited to small areas with limited vertical and lateral extent. Statistical analysis of these data to determine maximum source-term concentrations is not likely to prove meaningful because of the limited number of detected concentrations and the sporadic extent of contamination. As a conservative assumption, the maximum

concentration of the contaminant was used as the source-term concentration of a contaminant for the models and exposure assessment.

Volatilization of contaminants in soil is dependent on depth of contamination and concentration of contaminant. A receptor is more likely to be exposed to contaminants present in shallower soils as compared to contamination deep within the subsoils (Johnson and Ettinger, 1991). Therefore, the depth of contamination was assumed to be equal to the shallowest soil sample which had a positive detection for that contaminant. The maximum concentration of that contaminant at the shallowest depth was used to estimate potential exposure concentrations.

Exposure to groundwater contamination is limited to off-site receptors. For the purposes of this report, it was assumed that the receptor was a resident located at the Base boundary. Exposure was evaluated for both measured and modeled concentrations.

Five monitoring wells were placed along the downgradient boundary of the site. Of these, only one well (MWBP-05) is located within the TCE and PCE groundwater plumes (Figures 6-3 and 6-4 of the RI report). Two monitoring wells are located on the periphery of the plumes (MWBP-12 and MWBP-06A). Given the limited number of samples collected within the plume at the point of exposure downgradient of the site, statistical analysis of the data for the purposes of estimating a maximum exposure concentration is unlikely to provide meaningful data. For the purposes of this report, the maximum detected concentration will be used as the exposure concentration. Similarly, the maximum measured concentration for upgradient monitoring wells will be used to estimate exposure to upgradient off-site receptors.

Receptors may be exposed to contaminants leaching into groundwater and migrating to a point of exposure. Leaching of contaminants into groundwater was modeled. Chemicals detected at all depths were considered as potential sources of groundwater contamination. The maximum contaminant concentration in soil was used as the source term. Potential groundwater concentrations were modeled from these sources.

TPH represent a group of chemicals, not a single compound. Modeling of the fate and transport of chemicals uses chemical-specific physicochemical properties to estimate chemical concentrations in different media. Given these values do not exist for TPH, chemical concentrations in groundwater could not be estimated using leachate models. Fate and transport models used to estimate contaminant concentrations are discussed below.

J.3.3 Fate and Transport Models

Fate and transport models are used to estimate contaminant concentrations at the point of exposure. These models included volatilization of contaminants from soil into air, leaching of contaminants into groundwater, and volatilization of contaminants from groundwater into indoor air. The following models and equations were used in this risk assessment.

J.3.3.1 Subsurface Soil Volatilization to Air Model

The emission rate of chemicals from subsurface soils was calculated by (EPA, 1988b):

$$Q = (Di)(Csi)(A)(Pt)^{4/3}(Mi)/(Dsc) \qquad \text{Eq. 3-1}$$

where:

Q	=	Contaminant emission rate, g/sec
Di	=	Air diffusion coefficient, cm^2/sec
Csi	=	Saturated vapor concentrations, g/cm^2 (Equation 3-2)
A	=	Contaminated area, 1.02×10^7 cm2 [105 ft x 105 ft]
Pt	=	Total soil porosity, 0.55 (site-specific)
Mi	=	Mass fraction of contaminant, kg/kg
Dsc	=	Effective depth of soil cover, cm.

The depth of contamination is equal to the depth of the shallowest detected concentration. For the purposes of this risk assessment, it was assumed that the contaminant was evenly distributed over the entire horizontal area at that depth. The horizontal area was assumed to be equal to the area of the bottom of the impoundment.

The saturated vapor concentration, Csi, was calculated by using the following equation (EPA, 1988):

$$Csi = (Pv)(MWi)/(R)(T) \qquad \text{Eq. 3-2}$$

where:

Csi	=	Saturated vapor concentration, g/cm^3
Pv	=	Contaminant vapor pressure, mm Hg
Mwi	=	Molecular weight of contaminant I, g/mole
R	=	Molar gas constant, mm Hg • cm^3/mole °K
T	=	Temperature, 293 °K (assumption from Hillel, 1980).

The dispersion of volatiles into the air was estimated using the Nearfield Box Model (GRI, 1988);

$$Ca = \frac{Q \times CF}{Hb \times Wb \times Um} \qquad \text{Eq. 3-3}$$

where:

Ca	=	Chemical concentration in air, mg/m^3
Q	=	Emission rate of contaminant, g/sec (Equation 3-1)
CF	=	Conversion factor, 1,000 mg/g
Hb	=	Downwind exposure height, 2 m (default value from EPA, 1996)
Wb	=	Width of contaminated area perpendicular to wind direction, 45.3 m
Um	=	Average wind speed, 1.18 m/s [0.22 (U_{10})]
U_{10}	=	Windspeed at 10 m aboveground surface, 5.36 m/sec (NOAA, 1996).

The contaminant concentrations in outdoor air used to estimate exposure of the construction worker and Base personnel are given in Table J-3-1.

J.3.3.2 Subsurface Soil Volatilization to Indoor Air Model

The concentration of contaminants in a hypothetical building were calculated using the algorithm described in a paper by Johnson and Ettinger (1991). When possible, site-specific data were used. In the absence of site-specific data, the assumptions in the paper were used. It is assumed that the contaminated area of the site is completely covered by a building 150 feet by 150 feet, which is 6 m tall (site-specific conditions) and has a basement which extends one meter below the surface. All of the buildings currently on the Base do not have basements and are built on slabs. However, for the purposes of this model, it will be assumed that this structure has a basement.

The equations from Johnson and Ettinger (1991) used to estimate the indoor concentrations are listed below, followed by a justification for some of the parameter values. The input parameters are also listed in Table J-3-2. The parameter values are defined in alphabetical order after all the equations are listed because there are multiple equations which are linked together to yield the indoor air concentrations.

$$C_{build} = \frac{C^*_{build} \times \left[\exp\left(\frac{Q_{soil}\, L_{crack}}{D^{crack}\, A_{crack}}\right)\right]}{\left[\exp\left(\frac{Q_{soil}\, L_{crack}}{D^{crack}\, A_{crack}}\right)\right] + \left[\frac{D_T^{eff}\, A_B}{Q_{build}\, L_T}\right] + \left[\frac{D_T^{eff}\, A_B}{Q_{soil}\, L_T}\right]\left[\exp\left(\frac{Q_{soil}\, L_{crack}}{D^{crack}\, A_{crack}}\right) - 1\right]} \qquad \text{Eq. 3-4}$$

$$C^*_{build} = \left[\frac{D_T^{eff}\, A_B\, C_{source}}{Q_{build}\, L_T}\right] \qquad \text{Eq. 3-5}$$

where:

$$C_{source} = \frac{H'\, C_s\, \rho_b}{\theta_w + K_d\, \rho_b + H'\, \theta_a} \qquad \text{Eq. 3-6}$$

given:

$$\theta_a = \theta_T - \epsilon\rho_b \qquad \text{Eq. 3-7}$$

$$\theta_w = \epsilon\, \rho_b \qquad \text{Eq. 3-8}$$

$$D_T^{eff} = D_a^{eff} = D^{air}\frac{\theta_a^{3.33}}{\theta_T^2} \qquad \text{Eq. 3-9}$$

$$Q_{soil} = \frac{2\pi\, \Delta P\, k_v\, X_{crack}}{\mu\, \ln[2Z_{crack}/r_{crack}]} \qquad \frac{r_{crack}}{Z_{crack}} \ll 1 \qquad \text{Eq. 3-10}$$

where:

$$r_{crack} = \eta\ A_B/X_{crack} \qquad \text{Eq. 3-11}$$

$$A_{crack} = \eta \times A_B \qquad \text{Eq. 3-12}$$

where:

A_B	=	Area of basement, 2.09 x 0^7 cm^2
A_{crack}	=	Area of the cracks, 2.09 x 10^5 cm^3 (Equation 3-7)
C_{build}	=	Contaminant concentration in building, g/cm^3 (Equation 3-4)
C^*_{build}	=	Contaminant concentration in a building with a bare soil foundation, g/cm^3 (Equation 3-4)
C_s	=	Soil bulk concentration, g/g (chemical-specific)
C_{source}	=	Vapor phase contaminant concentration within the soil at the source, g/cm^3 (Equation 3-6)
D_a^{eff}	=	Effective diffusion coefficient in air-filled spaces within the soil, cm^2/sec
D^{air}	=	Pure component molecular diffusivity in air, cm^2/sec (chemical-specific)
D^{crack}	=	Diffusion coefficient through the cracks, $D^{crack} = D_t^{eff}$ (Johnson and Ettinger, 1991)
D_T^{eff}	=	Effective diffusion coefficient for soils underlying the building, extending from the source of contamination to the basement, cm^2/sec (chemical-specific) (Equation 3-5)
H'	=	Dimensionless Henry's law constant, unitless, (chemical-specific)
K_d	=	Soil-water partition coefficient, cm^3/g (chemical-specific)
k_v	=	Soil permeability [1 x 10^{-9} cm^2 for silty sand from Johnson and Ettinger (1991)]
L_{crack}	=	Thickness of the building foundation, 15 cm (Johnson and Ettinger, 1992)
L_T	=	Source-building separation, cm (chemical-specific)
Q_{build}	=	Building ventilation rate, [0.5/h X volume of the building (Johnson and Ettinger, 1991) = 46 m x 46 m x 6 m] = 1.74 x 10^6 cm^3/s]
Q_{soil}	=	Volumetric flow rate of soil gas into the building, 69.4 cm^3/s (Equation 3-13)
r_{crack}	=	Radius of a hypothetical cylinder used to estimate vapor flow into the basement of the hypothetical building, 1.14 cm (Equation 3-11, See text below)
X_{crack}	=	Length of hypothetical cylinder used to estimate vapor flow into the basement of the hypothetical building. Length is equal to the total floor/wall seam perimeter distance, 18,288 cm (See text below)
Z_{crack}	=	Depth of hypothetical cylinder used to estimate vapor flow into the basement of the hypothetical building. Depth of cylinder is equal to depth of the basement, 100 cm (see text below)
ΔP	=	Change in vapor pressure between the building and the soil, 10 g/cm-s^2 (assumption from Johnson and Ettinger, 1991)
ϵ	=	Soil moisture, 0.162 g/g

μ	=	Vapor viscosity, 1.8 x 10^{-4} g/cm-s^2 (Johnson and Ettinger, 1991)
η	=	Ratio of area of cracks and the area of the building, 0.001. (Assumption from Johnson and Ettinger, 1991; See text below)
θ_a	=	Soil air-filled porosity, 0.218 unitless (Equation 3-4)
θ_T	=	Total soil porosity, 0.51 unitless
θ_w	=	Soil water-filled porosity, 0.293 unitless
ρ_b	=	Soil dry bulk density, 1.75 g/cm^3.

Justification of Select Input Parameters. Johnson and Ettinger (1991) assumed that the building has a crack extending along the wall/floor seam, which extended the entire perimeter of the basement. Assuming that flow from soil into the building would be similar to diffusion into a cylinder, the cylinder would have a length X_{crack}, equal to the building perimeter. The cylinder would have a radius which is proportional to the area of the crack, as shown in Equation 3-6. The depth of the cylinder would be equal to the depth of the basement given that the crack theoretically exists along the wall/floor seam.

The soil permeability K_v, was selected at the lower end of the range because the soil at this site is tightly packed, more closely representing silty conditions.

The ratio of the area of the crack to the area of the building (η) is an assumed value. Values in Johnson and Ettinger (1991) range from 0.01 to 0.001. The lower end of the range was selected to maintain the validity of the assumption for Equation 3-6 that $r_{crack}/Z_{crack} << 1$.

For the purpose of this study, it is assumed that dirt-filled cracks will have the same diffusion coefficient as the soil underlying it. Therefore D^{crack} is equal to D_T^{eff} (Equation 3-5).

The concentration of contaminants in indoor air are listed in Table J-3-3.

J.3.3.3 Leachate Model (Revised Summers Model; Summers, et al., 1980)

This model was used to estimate the concentration in groundwater as a result of chemicals detected in soil samples leaching through the unsaturated zone. The modeled concentration is used to calculate exposure to potential receptors via different groundwater exposure pathways.

The Summers Model is a common and simplistic/conservative model and has been used to evaluate various sites throughout the United States. The model does not take into account numerous factors which are likely to reduce the concentration of contaminants in leachate. This reduces the amount of site-specific data required for the model; therefore, the model is applicable

at various types of sites. A discussion of the Summers Model is given in Section J.7.3.2 (Exposure Point Concentrations) in the uncertainty discussion.

The Summers model is:

$$C_{gw} = \frac{(Q_p \ x \ C_p) + (Q_a \ x \ C_a)}{Q_p + Q_a} \qquad \text{Eq. 3-13}$$

$$Q_p = V_{dz} \times A_p \qquad \text{Eq. 3-14}$$

$$C_p = \frac{C_s}{K_d} \qquad \text{Eq. 3-15}$$

where (Mills et. al., 1985):

$$K_d = K_{oc}[0.2(1-f)(X_{oc}^s) + (f)(X_{oc}^f)] \qquad \text{Eq. 3-16}$$

given (Mills et. al., 1985):

$$K_{oc} = 0.63 \times K_{ow} \qquad \text{Eq. 3-17}$$

$$Q_a = V_{dx} \times h \times w \qquad \text{Eq. 3-18}$$

where:

A_p = Horizontal area of spill, 11,025 ft^2 [105 ft x 105 ft]
C_a = Initial or background concentration of chemical in aquifer, 0 µg/L (assumed to be zero in this calculation)

C_{gw} = Chemical concentration in groundwater as a result of leachate, μg/L (Equation 3-8)
C_p = Chemical concentration in infiltration water, μg/L (Equation 3-10)
C_s = Chemical concentration in soil, μg/kg
f = Mass fraction of silt or clay, 0.5 (IT, 1992b)
h = Aquifer thickness, 15 ft (IT, 1992b)
K_d = Chemical specific water/soil partition coefficient, L/kg (Equation 3-10)
K_{oc} = Contaminant organic-carbon partitioning coefficient (Equation 3-10)
K_{ow} = Contaminant octanol-water partitioning coefficient
Q_a = Volumetric flow rate of groundwater, 299,250 ft^3/day (Equation 3-11)
Q_p = Volumetric flow rate of infiltration into the aquifer, 2.5 ft^3/day (Equation 3-9)
V_{dx} = Horizontal Darcy velocity, 133 ft/day (IT, 1992)
V_{dz} = Darcy velocity in downward direction, assumed 1" per year = 2.28×10^{-4} ft/day (IT, 1992a)
w = Width of spill perpendicular to flow direction in aquifer (105 x 1.414=150 ft).
X_{oc}^s = Organic carbon content of sand, 0.5% (IT, 1992b)
X_{oc}^f = Organic carbon content of silt/clay, 1% (IT, 1992b)

The K_d values for the contaminants are given in Table J-3-4.

The Summers Model estimates the contaminant concentration in groundwater directly below the site. As a conservative measure, it was assumed that contaminant concentrations at the edge of the Base are equal to the concentrations directly below the site. Calculated, or modeled, groundwater concentrations via leaching are given in Table J-3-5.

Indoor Air Model. The model used to estimate chemical concentrations in household air from general household water use follows EPA (1991):

$$C_a = C_w \times K \times CF \qquad \text{Eq. 3-19}$$

where:

C_a = Contaminant concentration in indoor air, mg/m^3
C_w = Contaminant concentration in tap water, mg/L
K = Volatilization factor, unitless
CF = Conversion factor.

Contaminant concentrations in indoor air from groundwater are given in Table J-3-6.

Contaminant concentrations at the point of exposure are used in exposure models to estimate potential intakes of COPC.

J.3.4 Quantification of Intake of Chemicals of Potential Concern

Chemical exposure is quantitatively estimated in terms of chemical intake and is expressed as the mass of substance in contact with the body per unit body weight per unit time (milligram of chemical/kilogram of body weight/day). The magnitude of exposure to a chemical is a function of a number of variables that describe the activity patterns and exposure characteristics of the receptor population. These variables include exposure time, exposure frequency, exposure duration, skin surface area, skin absorption factor, water ingestion rate, inhalation rate, body weight, and averaging time. In order to quantify exposure, these parameters are assigned numerical values based on site-specific data and EPA-recommended default values. These numerical values are incorporated into EPA-derived equations for the quantification of chemical exposure for each identified exposure pathway and each receptor population.

The risk assessment uses the RME scenarios for all receptor populations. The RME uses exposure assumptions that represent the reasonable upper bound exposure for receptor populations at the site. Central tendency exposure will be estimated for those receptors which had shown a potential adverse health impact for the RME. The intake model variables for central tendency calculations generally reflect 50 percentile values (EPA, 1992b). The exposure concentrations for the RME are the 95 percent UCL of the arithmetic mean or the maximum concentration, depending on which is lowest (EPA, 1992b). The concentration used for evaluating central tendency or "average" exposure scenario is the arithmetic mean (EPA 1989). As previously discussed, the data available are limited and are not considered to be sufficient for viable statistical analysis. Therefore, the maximum concentration was used for source-terms in modeling and estimation of potential exposures. The central tendency receptor was evaluated to demonstrate the conservatism in the estimated intake for the RME.

Intakes are presented separately for carcinogenic chemicals and systemic toxicants because averaging times are used in estimating intakes. For COPC judged to be potential carcinogens, intakes are averaged over the estimated lifetime of the receptor. For systemic toxicants, intakes are averaged over the estimated duration of the exposure.

The primary source for the exposure models used for this risk assessment are the *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual* (EPA, 1989a) and the *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and*

Permitted Facilities (CalEPA, 1992). These exposure models are discussed in the following sections. Estimated intakes for the receptor populations are given in the Risk Characterization section.

J.3.4.1 Inhalation of Volatile Emissions from Soil

This equation estimates the intake of chemicals by a potential receptor (i.e., the construction worker or Base worker on site) via inhalation of chemicals volatilizing from soil:

$$Intake = \frac{C_a \times IhR \times EF \times ED}{BW \times AT} \qquad \text{Eq. 3-20}$$

where:

C_a = Chemical concentration in air, mg/m^3
IhR = Inhalation rate, m^3/d
EF = Exposure frequency, days/year
ED = Exposure duration, years
BW = Body weight, kg
AT = Averaging time, days.

The chemical concentrations in outdoor air are given in Table J-3-1. Exposure factors for the various on site receptor populations are given in Table J-3-7.

J.3.4.2 Dermal Contact with Chemicals in Water

This equation estimates the intake of chemicals by a potential receptor (i.e. the hypothetical resident) via dermal contact with chemicals during showering:

$$Intake = \frac{C_w \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT} \qquad \text{Eq. 3-21}$$

where:

C_w = Chemical concentration in water, mg/L
SA = Surface area of skin, cm^2
PC = Dermal permeability constant, cm/hr
CF = Volumetric conversion factor for water, 1 L/1000 cm^3

The dermal permeability constants were obtained from the EPA's *Dermal Exposure Assessment: Principles and Applications* (EPA, 1992c). In the absence of a published value the following formula was used to estimate the dermal permeability constant (EPA, 1992c):

$$\log K_p = -2.72 + 0.71 \log K_{ow} - 0.0061 MW \qquad \text{Eq. 3-22}$$

where:

K_p = dermal permeability constant, cm/hr
K_{ow} = octanol-water partitioning coefficient, unitless
MW = molecular weight, g

The dermal permeability constants for the COPC are given in Table J-3-8. Contaminant concentrations in water are given in Table J-3-6. Exposure assumptions for dermal exposure of the receptor populations are given in Table J-3-9.

J.3.4.3 Ingestion of Drinking Water

This equation estimates the intake of chemicals by a potential receptor (i.e. the hypothetical resident) via the drinking water pathway.

$$Intake = \frac{C_w \times IR_w \times EF \times ED}{BW \times AT} \qquad \text{Eq. 3-23}$$

where:

C_w = Chemical concentration in water, mg/L
IR_w = Ingestion rate of water, L/day

Contaminant concentrations in water are given in Table J-3-6. Exposure assumptions for exposure of residential receptor populations via drinking water are given in Table J-3-10.

J.3.4.4 Inhalation of Volatiles from Household Water Use

This equation estimates the intake of chemicals by a potential receptor (i.e. the hypothetical resident) via inhalation of volatiles during household water use:

$$Intake = \frac{C_w \times K \times CF \times IhR \times EF \times ED}{BW \times AT} \qquad \text{Eq. 3-24}$$

where:

K = Volatilization constant, 0.5 L/m^3 (EPA, 1991a)
CF = Conversion factor, 1000 L/m^3.

Contaminant concentrations in water are given in Table J-3-6. Exposure assumptions for exposure by receptor populations via inhalation are given in Table J-3-11.

J.4.0 Toxicity Assessment

The toxicity assessment evaluates information concerning the potential adverse effects of the COPC identified in Section J.2.0. This section presents a brief discussion of the methodology by which the cancer and noncancer effects of chemicals are evaluated qualitatively and quantitatively.

J.4.1 Carcinogenicity

Many chemicals are known or suspected to be human carcinogens. The evaluation of the potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA, 1986). The qualitative aspect is a weight-of-evidence evaluation of likelihood that a chemical might induce cancer in humans. The EPA recognizes six weight-of-evidence group classifications for carcinogenicity:

- ***Group A - Human Carcinogen.*** Data in humans are sufficient to identify the chemical as a human carcinogen
- ***Group B1 - Probable Human Carcinogen.*** Human data indicate a causal association is credible, but alternative explanations cannot be dismissed
- ***Group B2 - Probable Human Carcinogen.*** Human data are insufficient to support a causal association, but testing data support a causal association in animals
- ***Group C - Possible Human Carcinogen.*** Human data are inadequate or lacking, but animal data suggest a causal association, although the studies have deficiencies that limit interpretation
- ***Group D - Not Classifiable as to Human Carcinogenicity.*** Human and animal data are lacking or inadequate
- ***Group E - Evidence of Noncarcinogenicity to Humans.*** Human data negative or lacking, and adequate animal data indicate no association with cancer.

The quantitative evaluation is an estimate of carcinogenic potency. Potency estimates are developed only for chemicals in Groups A, B1, B2, and C. The potency estimates are statistically derived from the dose-response curve from the best human or animal study or studies with the chemical. In the case of animal studies, pharmacokinetic data or principles are used to estimate an equivalent human dose. The estimate, which is also called the cancer slope factor (SF), is expressed as risk per unit dose (per mg/kg-day). The SF, when multiplied by the dose

estimated in the exposure assessment, yields a quantitative estimate, or probability, of risk. In order to be appropriately conservative, the SF is usually the 95 percent upper bound on the slope of the dose-response curve extrapolated from high (experimental) doses to the low-dose range expected in environmental exposure scenarios. It is assumed that there are no thresholds for carcinogens; therefore, any exposure represents some quantifiable risk. The discussion of chemical carcinogenicity includes the EPA's classification of carcinogenicity and the cancer SF recommended by the EPA. The cancer SF presented are for discussion purposes only. The cancer SF used in evaluating the carcinogenic risks associated with exposure to the COPC were obtained from the Office of Environmental Health Hazard Assessment, California Environmental Protection Agency (CalEPA, 1994c). The cancer SF are compiled in Table J-4-1.

J.4.2 Noncancer Effects

Many chemicals, whether or not associated with carcinogenicity, are associated with non-carcinogenic effects. The evaluation of noncancer effects (EPA, 1989c) involves:

- Qualitative identification of the adverse effect(s) associated with the chemical; these may differ depending on the duration of exposure (acute, subchronic, chronic)

- Identification of the critical effect (or threshold effect) for each duration of exposure, i.e., the adverse effect that occurs at the lowest dose (e.g., if liver damage occurs at 20 mg/kg-day, and mortality occurs at 100 mg/kg-day, liver damage is the critical effect)

- Quantification of the threshold dose for the critical effect for each duration of exposure (i.e., the dose at or above which the effect occurs, and below which the effect does not occur

- Development of an uncertainty factor, i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of the critical effect and slope of the dose-response curve, and deficiencies in the database, in regard to developing a reference dose (RfD) for human exposure

- Identification of the target organ(s) for the critical effect for each route of exposure.

The information points described above are used to derive an exposure route- and duration of exposure-specific RfD, expressed as mg/kg-day, which is considered to be the dose for humans at which adverse effects are not expected to occur. Mathematically, it is estimated as the ratio of the threshold dose to the uncertainty factor. The dose estimated in the exposure assessment divided by the RfD is a quantitative but non-probabilistic expression of the likelihood that an adverse effect might occur. RfD are derived separately for oral and inhalation exposure

pathways because of possible differences in the rate of absorption, target organs and mechanisms of toxicity.

Inhalation RfD were not available for all COPC. California EPA guidance states that in the absence of inhalation RfD, the oral RfD will be used as a surrogate value (Cal EPA, 1994c). It should be noted that the oral RfD value is not corrected for differences in absorption rates but is used directly as the inhalation RfD.

The polyaromatic hydrocarbon (PAH) phenanthrene did not have an oral RfD; therefore, a surrogate chemical will be used to evaluate the toxicity of this chemical. Surrogate chemicals are based on similarities in chemical structure, toxic effects and potency. Oral toxicity data for phenanthrene and indeno(1,2,3-c,d)pyrene are all but nonexistent (ATSDR, 1993). Therefore, similarity in structure is the only criterion on which to base selection of an oral RfD. Of the PAH for which oral RfD are available, anthracene is structurally most similar to phenanthrene. Therefore, the oral RfD for anthracene will be used for the oral and inhalation RfD for phenanthrene. Pyrene is structurally most similar to indeno(1,2,3-c,d)pyrene. Therefore, the oral RfD for pyrene will be used for the oral and inhalation RfD for indeno(1,2,3-c,d)pyrene. The RfD for the COPC are compiled in Table J-4-2.

J.4.3 Dermal Evaluation of Chemicals

Dermal RfD and SF values were derived from the corresponding oral values. In the derivation of a dermal RfD, the oral RfD was multiplied by the gastrointestinal absorption factor (GAF), expressed as a unitless fraction. The resulting dermal RfD is an RfD based on absorbed dose, which is the appropriate value with which to compare a dermal dose because dermal doses are expressed as absorbed rather than exposure doses. In a similar manner, and for the same reasons, a dermal SF is derived by dividing the oral cancer slope factor by the GAF. A default GAF value (0.5), which is the GAF values for benzo(a)pyrene (Jones and Owen, 1989) was adopted for the PAH. A default GAF value (0.9), which is an average of published GAF values for organic chemicals (Jones and Owen, 1989), was adopted for chemicals without a specific GAF value. Chemical-specific GAF values are presented in Table J-3-8.

A group of PAH, including benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene and chrysene are classified in EPA cancer weight-of-evidence Group B2, which means that, on the basis of animal studies, they are considered to be "probable human carcinogens." The B2 PAHs are contact carcinogens, i.e., in animal studies they induce cancer in the organ or system with which they make contact.

For example, when given orally to laboratory rodents, they induce cancer of the forestomach, when given intratracheally or implanted in the lung, they induce lung cancer, and when solutions are painted on the skin of mice, they induce skin cancer. No EPA methodology currently exists to quantify the risk of developing skin cancer from dermal exposure to the B2 PAHs.

J.4.4 Toxicity Profiles

Separate toxicity profiles for each COPC are not necessary because the toxicity values presented in the risk characterization tables in Section J.5.0 are adequate for quantitative analyses and discussion of uncertainty. Sources for toxicity values for cancer and noncancer effects are indicated in Tables J-4-1 and J-4-2. Toxicity profiles for the dichloroethenes, trichloroethene, and tetrachloroethene are provided below. They have been detected more frequently in groundwater.

J.4.4.1 cis-1,2-Dichloroethene

cis-1,2-Dichloroethene (Chemical Abstract Services [CAS] Reg. No. 156-59-2), also known as c-1,2-dichloroethylene is a volatile organic compound with a molecular weight of 96.94 (ATSDR, 1990), a Henry's law constant of 0.00451 atm-m^3/mol at 25°C, a water solubility of 4.94 g/kg at 20 to 25°C, and a log K_{ow} of 1.68 (EPA, 1994c). 1,2-Dichloroethene is used primarily as a chemical intermediate in the synthesis of chlorinated solvents and compounds; it has also been used as a low temperature extraction solvent (ATSDR, 1990).

Noncancer Toxicity. Repeated oral exposure of rats to cis-1,2-dichloroethene was associated with signs of anemia (decreased hematocrit and hemoglobin) (EPA, 1993c). Inhalation exposure to isomeric mixtures of 1,2-dichloroethene induced narcosis, and mixed isomers of 1,2-dichloroethene were used as an anesthetic gas (ACGIH, 1986). EPA (1993c) presents a provisional chronic oral RfD of 0.01 mg/kg-day based on a NOAEL for signs of anemia in rats and an uncertainty factor of 3,000. A provisional subchronic oral RfD of 0.1 mg/kg-day was derived from the same no-observed-adverse-effect-level (NOAEL) and an uncertainty factor of 300. Target organs appear to be the erythrocyte for oral exposure and the central nervous system (CNS) for inhalation exposure.

Carcinogenicity. EPA (1994b) classified cis-1,2-dichloroethene as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans), based on an absence of human or animal cancer data. Quantitative estimates of cancer risk are not derived for Group D chemicals.

J.4.4.2 trans-1,2-Dichloroethene

trans-1,2-Dichloroethene (CAS Reg. No. 156-60-5), also known as t-1,2-dichloroethylene is a volatile organic compound with a molecular weight of 96.94 (ATSDR, 1990), a Henry's law constant of 0.00938 atm-m^3/mol at 25°C, a water solubility of 8.03 g/kg at 20 to 25°C, and a log K_{ow} of 1.98 (EPA, 1994c). 1,2-Dichloroethene is used primarily as a chemical intermediate in the synthesis of chlorinated solvents and compounds; it has also been used as a low temperature extraction solvent (ATSDR, 1990).

Noncancer Toxicity. The oral LD_{50} for trans-1,2-dichloroethene in rats mg/kg; death was preceded by CNS and respiratory depression (ACGIH, 1986). Histopathologic examination revealed lesions in the lungs and heart. Prolonged oral administration induced clinicopathologic evidence of mild liver damage (EPA, 1993b). A NOAEL for this effect in a 90-day drinking water study in mice and an uncertainty factor of 1,000 was the basis for a verified chronic oral RfD of 0.02 mg/kg-day. A provisional subchronic oral RfD of 0.2 mg/kg-day was derived from the same NOAEL and an uncertainty factor of 100 (EPA, 1993c). The target organs for inhalation exposure to trans-1,2-dichloroethene are the CNS, heart and lungs. The liver appears to be the principal target of oral exposure.

Carcinogenicity. Data regarding the carcinogenicity of trans-1,2-dichloroethene were not located.

J.4.4.3 Trichloroethene

Trichloroethene (CAS Reg. No. 79-01-6) is a volatile organic compound with a molecular weight of 131.40, Henry's law constants of 0.020 atm-m^3/mol at 20°C and 0.011 atm-m^3/mol at 25°C, water solubilities of 1.070 g/kg at 20°C and 1.366 g/kg at 25°C, and a log K_{ow} of 2.42 (ATSDR, 1988). It is used as a solvent and as a substrate in organic synthesis.

Noncancer Toxicity. Acute inhalation exposure to high levels of trichloroethene (TCE) induces anesthesia, tachypnea and ventricular arrhythmias (ACGIH, 1986). Occupational exposure is associated with headache, dizziness, lassitude, and other CNS effects. Prolonged inhalation exposure of laboratory animals affects the liver and kidneys. Neither oral nor inhalation RfD or reference concentration (RfC) values were located for TCE. The principal target organs for TCE are the CNS and heart, and, to a lesser extent, the liver and kidney.

Carcinogenicity. Carcinogenicity studies in laboratory animals show increased incidence of hepatocellular carcinomas (gavage exposure) and malignant lymphomas (inhalation exposure) in mice, and increased incidence of renal adenocarcinomas in male rats (gavage) (EPA, 1988c). Cancer studies in humans are inadequate to assess the carcinogenicity of TCE. Interpretation of the data regarding the carcinogenicity of TCE is controversial, and the EPA (1992b) has not adopted a final position on a cancer weight-of-evidence classification or quantitative risk estimates for trichloroethene. For this reason, trichloroethene was removed from the EPA (1994b) Integrated Risk Information System (IRIS) database and the 1992 Health Effects Assessment Study Table (HEAST) (EPA, 1992c). Currently, the EPA (1992b) judges the weight-of-evidence to be on the C-B2 continuum (possible-probable human carcinogen), and offers slope factors of 0.011 per mg/kg-day for oral exposure and 0.006 per mg/kg-day for inhalation exposure as being useful.

J.4.4.4 Tetrachloroethene

Tetrachloroethene (CAS Reg. No. 127-18-4) also known as perchloroethene (PCE) is a volatile organic compound with a molecular weight of 165.82, a Henry's law constant of 0.017 atm-m^3/mol, water solubility of 1.503 mg/L 25°C, and a log K_{ow} of 3.40 (Howard, 1990). It is used as a solvent and as a substrate in organic synthesis (ATSDR, 1987).

Noncancer Toxicity. Occupational (inhalation and dermal) exposure to PCE is associated with neurologic effects, beginning with incoordination and progressing to dizziness, headache, vertigo and unconsciousness (ACGIH, 1986). Neither occupational nor animal inhalation data are sufficient to estimate an inhalation RfD. The EPA (1994b) presents a verified chronic oral RfD for PCE of 0.01 mg/kg-day based on a NOAEL for liver toxicity in mice in a subchronic gavage study, and on a no-observed-effect-level (NOEL) for depressed body weight gain in rats in a subchronic drinking water study. An uncertainty factor of 1000 was used. The EPA (1993c) presents a provisional subchronic oral RfD of 0.1 mg/kg-day based on the same NOEL and an uncertainty factor of 100. The CNS is the principal target organ for inhalation exposure. The liver is the principal target organ for oral exposure to PCE.

Carcinogenicity. Inhalation exposure to PCE induced mononuclear cell leukemia in rats, and inhalation or oral exposure induced hepatocellular carcinomas in mice (ATSDR, 1987). Occupational exposure data do not suggest a carcinogenic role for PCE in humans (ACGIH, 1986). Interpretation of the data regarding the carcinogenicity of PCE is controversial, and the EPA (1992b) has not adopted a final position on the cancer weight-of-evidence classification or quantitative risk estimates for PCE. For this reason, the cancer evaluation of PCE was removed

from the 1992 HEAST (EPA, 1992c). Currently, the EPA (1992b) believes the weight-of-evidence to be on the C-B2 continuum (possible-probable human carcinogen), and offers slope factors of 0.052 per mg/kg-day for oral exposure and 0.002 per mg/kg-day for inhalation exposure as being useful.

J.5.0 Risk Characterization

This section provides a characterization of the potential health risks associated with the intake of chemicals originating from the Base. Section J.5.1 presents the methods used to estimate the types and magnitudes of health effects associated with exposure to chemicals. Section J.5.2 presents the results of risk assessment calculations for measured and modeled concentrations of chemicals at the ANG.

J.5.1 Methodology

Potential risks to humans following exposure to COPC are estimated using methods established by the EPA when available. Methods described by the EPA are health-protective and are likely to overestimate, rather than underestimate risk. Risks from hazardous chemicals are calculated for either carcinogenic or noncarcinogenic effects. Some carcinogenic chemicals may pose a noncarcinogenic hazard. Risks from these chemicals are characterized for both types of health effects.

J.5.1.1 Chemical Carcinogens

The risk attributed to exposure to chemical carcinogens is estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. At low doses (which are generally expected at Superfund sites), the risk of developing cancer is determined as follows (EPA, 1989a):

$$RISK = CDI \times SF \qquad \text{5-1}$$

where:

Risk = Risk of cancer incidence, expressed as a unitless probability
CDI = Chronic daily intake or dose averaged over 70 years (mg/kg-day)
SF = Slope factor $(mg/kg\text{-}day)^{-1}$

For a given pathway with simultaneous exposure of a receptor to several carcinogens, the following equation is used to sum cancer risks:

$$Risk_p = Risk(chem_1) + Risk(chem_2) + \ldots\ Risk(chem_i) \qquad \text{5-2}$$

where:

$Risk_p$ = Total pathway risk of cancer incidence
$chem_i$ = Individual carcinogenic chemical.

Risks may be summed across pathways when exposures are simultaneous.

J.5.1.2 Chemical Noncarcinogens

The risks associated with the effects of noncarcinogenic hazardous chemicals are evaluated by comparing an exposure intake, or dose, to a RfD. The ratio of intake over the RfD is termed the hazard quotient (HQ) (EPA, 1989a) and is defined as:

$$HQ = I/RfD \tag{5-3}$$

where:

HQ = Hazard quotient (unitless)
I = Intake of chemical (mg/kg-day)
RfD = Reference dose (mg/kg-day) .

Chemical noncarcinogenic effects are evaluated on a chronic basis, using chronic RfD values. This approach is different from the probabilistic approach used to evaluate carcinogenic effects. A HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates that the estimated intake is 100 times lower than the RfD. A HQ of unity (1.0) indicates that the estimated intake equals the RfD. If the HQ is greater than unity, there may be concern for potential adverse health effects.

In the case of simultaneous exposure of a receptor to several chemicals, a hazard index (HI) was calculated as the sum of the HQs by:

$$HI = I_1/RfD_1 + I_2/RfD_2 + \ldots I_i/RfD_i \tag{5-4}$$

where:

HI = Hazard Index (unitless)
I_i = Intake for the i^{th} toxicant
RfD_i = Reference dose for the i^{th} toxicant.

J.5.2 Characterization of Risks

As developed in Section J.3.1.3, potential receptors include a hypothetical user of groundwater as a source of household water, and a construction and Base workers exposed to site soils. Exposure pathways evaluated for exposure to groundwater are drinking water ingestion, dermal contact during bathing, and inhalation of VOCs released from water during household use. The exposure pathway evaluated for soil is the inhalation of volatiles. Risks associated with a construction or Base worker exposed to soils are presented and discussed in Section J.5.2.1.

Potential noncarcinogenic risks associated with residential use of groundwater were evaluated for adult and child receptor populations. Carcinogenic risks were evaluated for the adult only because risks associated with carcinogens are based on exposure average over a lifetime. A child receptor population is unlikely to have carcinogenic risks greater than an adult receptor population given the lower exposure duration for the RME child receptor (6 years) as compared to the RME adult receptor (30 years). For the purposes of this study, the carcinogenic risks associated with a child resident receptor will not be evaluated. Risks associated with the household use of groundwater are presented and discussed in Section J.5.2.2.

J.5.2.1 Soils

On site receptors, including construction workers, Base employees working outside and Base employees working within a building, may be exposed to volatile organics via inhalation. Table J-5-1 presents the potential RME cancer risks and HIs for these potential receptors. The total ILCR for the construction worker is 6.2×10^{-13} (Table J-5-1). The total ILCRs for a Base employee working both outside and in a building is 3.2×10^{-7} (Table J-5-1). All of the ILCRs are below the lower limit of the target risk range of 10^{-6} to 10^{-4} (EPA. 1990).

The HI for the construction worker is 4.8×10^{-7} (Table J-5-1). The HI for a Base employees working outside and in a building is 6.5×10^{-3} (Table J-5-1). All of the HIs are at least two orders of magnitude below the target value of one (1.0).

It is unlikely that contaminants present in soils would have an adverse effect on the health of workers at the Base.

J.5.2.2 Groundwater

Exposure to groundwater was evaluated for a hypothetical residential receptor populations (adults and children) located off-site at the Base perimeter. Risk calculations were based on the concentrations of chemicals measured in groundwater at Site 5-BCP, and on the concentrations

of chemicals estimated by applying the Summers leaching model to chemicals in soil (Section J.3.4). In addition, exposure to groundwater was evaluated for the Base given a hypothetical receptor located at the Base perimeter upgradient of groundwater flow (i.e., where groundwater enters the Base property), and for another receptor located at the Base perimeter downgradient of groundwater flow (i.e., where groundwater leaves the Base property). This allows comparing the risk from exposure to groundwater before and after it enters the Base, providing information on the potential source of the major contaminants driving the potential risks associated with groundwater. Measured groundwater concentrations were used for receptors at the upgradient and downgradient Base perimeter locations.

RME Off-site Resident - Adult. The calculated risk values for Site 5-BCP groundwater and upgradient and downgradient monitoring wells are given in Table J-5-2 through J-5-4. The results are summarized in Table J-5-5. The total RME cancer risks for measured groundwater concentrations at Site 5-BCP are significantly higher than the risks associated with the modeled values. The total ILCR for the measured values is 5.3×10^{-5}, as compared to 1.3×10^{-8} for the modeled concentrations (Table J-5-5). It should be noted that the cancer risks associated with the measured concentrations reflects contamination from on-site migration of contaminants in groundwater from sources upgradient of the Base, in addition to contaminants from Site 5-BCP.

The total cancer risk for the measured concentrations was within the target risk range of 10^{-6} to 10^{-4} (EPA. 1990). The total risk value for the modeled concentrations is over an order of magnitude below the lower limit of the target risk range.

The total hazard index for the measured and modeled groundwater concentrations at Site 5-BCP are 7.6×10^{-1} and 3.3×10^{-3}, respectively (Table J-5-5). Both of these values are below the target value of one.

The total RME cancer risk across pathways was slightly higher for the upgradient location (ILCR = 3.8×10^{-4}) than for the downgradient location (ILCR = 2.5×10^{-4}) (Table J-5-5). The greater cancer risk at the upgradient location is due largely to trichloroethene (ILCR = 3.2×10^{-4}) and 1,2-dichloropropane (ILCR = 4.6×10^{-5}). The ILCRs associated with these chemicals downgradient of the Base are 2.6×10^{-5} (TCE) and 1.4×10^{-5} (1,2-dichloropropane). The greatest risk driver downgradient of the Base was PCE (ILCR = 1.7×10^{-4}). The cancer risks for both the upgradient and downgradient locations are higher than the upper limit of the target risk range, 10^{-4}.

A similar pattern was noted for the RME noncancer estimations; i.e. upgradient HIs were higher than downgradient HIs for all pathways: ingestion, dermal contact, and inhalation of volatiles (Tables J-5-1 through J-5-4). The total RME HI across pathways is greater for the upgradient location (HI = 12.7) than for the downgradient location (HI = 2.9). The larger HI at the upgradient location is due to trichloroethene (HQ = 11.3) and 1,2-dichloropropane (HQ = 1.1). The predominant risk driver in the downgradient wells is PCE (HQ = 1.2). Trichloroethene and 1,2-dichloropropane have HQs of 0.7 and 0.4, respectively, in the downgradient wells.

As noted above, the total RME cancer risks for both the upgradient and downgradient locations are higher than the upper limit of the target risk range, 10^{-4}. However, the RME HI for the upgradient and downgradient location exceeds one (1.0). Therefore, the cancer and noncancer risk estimates for upgradient and downgradient locations were recalculated using the intake model variables for central tendency presented in the BRAWP (IT, 1993a) and maximum concentrations for the chemicals present in groundwater.

RME Off-site Resident - Child. Children may be at greater potential risks than adults from exposure to noncarcinogenic chemicals, because of differences in their behavior and physiology may result in a higher daily dose. Risks resulting from exposure to chemical carcinogens are estimated based on an average lifetime dose or dose averaged over 70 years. Given the lower exposure duration for a child resident relative to an adult (6 years for a child as compared to 30 years for an RME adult), the average daily dose will be less (CalEPA, 1994c). Therefore, the risk characterization for the child resident will only evaluate potential noncarcinogenic risks, if the maximum potential carcinogenic risks associated with groundwater are associated with the RME adult resident scenario (CalEPA, 1996).

The calculated risk values for Site 5-BCP groundwater and upgradient and downgradient monitoring wells are given in Table J-5-6. The HIs for the measured and modeled groundwater concentrations at Site 5-BCP are 7.5×10^{-1} and 8.8×10^{-4}, respectively. Both of these values are below the target value of one. If the cancer risks are within the acceptable range and the HIs for groundwater are below one, it is unlikely that chemicals present in groundwater will have an adverse noncarcinogenic effect on health of this receptor population.

The HIs for the upgradient and downgradient wells are 12.1 and 2.8, respectively (Table J-5-6). Both of these HIs exceed the target value of one. Tricholoroethylene was the only chemical upgradient of the Base that had a HI exceeding one (TCE HQ = 11.2). The downgradient well tricholoroethylene and PCE had the highest HIs, 0.9 and 1.4, respectively.

The HIs for upgradient and downgradient monitoring wells are above target value of one. Usually an analysis of the central tendency would be done to evaluate the potential risks associated with average exposure parameter values. However, the values for the exposure parameters for the RME and the central tendency are the same for the child receptor (Tables J-3-7 to J-3-9). The central tendency analysis uses a mean contaminant concentration for estimating risk. Based on the limited number of samples, statistical analysis of the data was not considered appropriate, and the maximum concentration is used for both the RME and central tendency analysis. Therefore, there is no difference in risk for RME and a central tendency exposure scenario for a child receptor.

Central Tendency (CT) Off-site Resident - Adult. As noted above, the total RME cancer risks for both the upgradient and downgradient locations exceed the target range of 10^{-6} to 10^{-4} (Table J-5-5). In addition, the RME HI for the upgradient and downgradient locations (Table J-5-5) exceeds one (1.0). Therefore, the cancer and noncancer risk estimates for both locations were recalculated using the intake model variables for central tendency and maximum concentrations for the chemicals (Tables J-5-7 through J-5-10). As expected, the risk results patterns discussed above for the RME evaluation (i.e., the larger total cancer risk and HI at the upgradient location compared with the downgradient location) remained unchanged, as did the risk drivers. Cancer risks for the CT evaluation, however, fall within the target range for both the upgradient location (7.9×10^{-5}, Table J-5-10) and the downgradient location (5.2×10^{-5}, Table J-5-10). The CT HI for the upgradient receptor of 7.0 (Table J-5-10) and the downgradient receptor of 1.6 (Table J-5-10) exceeds the acceptable limit of 1.0.

Based on the analysis of this data, contaminants present in groundwater may present a potential noncarcinogenic health hazard to adult residential users of groundwater.

J.5.3 Discussion of Results

Risks from exposure to soil at the ANG for construction activities or standard operations at the site are below the target risk range mandated by the EPA. Based on this analysis, contaminants in soils are not likely to have an adverse affect upon health of workers at the Base.

In essence, groundwater at the site is contaminated by organic constituents. Primary contributors to cancer risk are trichloroethene and tetrachloroethene, with 1,2-dichloropropane contributing to a smaller extent. Based on the comparison of concentrations and risks from upgradient and downgradient Base perimeter wells, it is concluded that tetrachloroethene is the only significant contaminant in groundwater derived from the Base activities. The total risk from downgradient

base perimeter wells is less than the total risk from upgradient base perimeter wells in large part due to the reduction in trichloroethene concentrations in downstream wells. Based on this analysis trichloroethene and tetrachloroethene may have adverse health affects on residential populations using the groundwater as a drinking water source.

J.6.0 Ecological Risk Assessment

The ecological risk assessment is generally composed of two parts, the scoping assessment and the predictive ecological risk assessment (CalEPA, 1994a; 1994b). The scoping assessment evaluates the types of contaminants present and the potential for exposure of ecological receptors. The predictive ecological risk assessment quantitatively evaluates the potential for adverse effects associated with exposure to these contaminants.

The scoping assessment consists of the environmental setting and the problem formulation. The environmental setting characterizes the physical and biotic conditions present at the Base. The problem formulation evaluates the nature and extent of contamination, possible migration and exposure pathways, and the types of ecological receptors that may be adversely effected as a result of exposure to site-related contaminants. The problem formulation is used to focus the Phase I (predictive ecological risk assessment) so that all sites that need to be addressed, and only those sites, are evaluated.

J.6.1 Environmental Setting

The environmental setting of the Base has been previously described in Chapter 3.0 of this report. The reader is referred to this section for a description of the meteorology, soils, geology, and hydrogeology.

The ANG leases 126.3 acres from the City of Fresno on three different parcels inside the boundaries of the Fresno Air Terminal (FANG, 1990). The majority of the land at the Base is either paved or has been developed (contains buildings or other structures used for the maintenance or support of military operations). Approximately 30 percent of the land is open.

The environment at the Base represents a controlled ecosystem. Vegetation consists primarily of shrubs, trees, or grasses that have been planted for the purposes of aesthetics or landscaping. There are small areas of ruderal vegetation scattered across the Base. Wildlife at the Base consists of animals adapted to surviving in highly developed areas. These organisms would include gophers, ground squirrels, mice, rats, rabbits, and passerine birds. There are no endangered or threatened species within one-mile radius of the Base (FANG, 1990).

J.6.2 Problem Formulation

Problem formulation is the first phase of an ecological risk assessment (ERA) and establishes the goals, breadth, and focus of the risk assessment (EPA, 1992c). Problem formulation consists of identifying COPC; exposures and ecological effects associated with contamination; identifying the assessment and measurement endpoints that will be evaluated; and developing an ERA conceptual model that describes how a given chemical (or other stressors) may affect the various ecological components being evaluated (EPA, 1992c).

The problem formulation includes the following:

- Biological characterization
- Identification of contaminants of concern
- Exposure pathways identification
- Assessment endpoint selection
- Selection of representative receptor species
- Site conceptual model.

This section will discuss each section of the problem formulation, including any procedures applied in selection of COPC, exposure pathways, etc. Each step in the problem formulation acts as a potential screening factor. For example, if there are no contaminants of concern or exposure pathways are absent, then further evaluation of the site is not required, based on ecological receptors not being exposed to contaminants.

J.6.2.1 Biological Characterization

The vegetative community present in the former pond was representative of early successional plant community. The pond was periodically dredged every three years to remove vegetation as part of a standard maintenance operation. The plant community present would be representative a successional community. After three years the plant community would be dominated by shrubs, bushes, with some tree saplings. Site 5-BCP is currently a level lot with some early successional plants present. Wildlife investigations of the site have not been performed, but based on the current lack of vegetation, it is unlikely that a significant faunal community is inhabiting the site.

Future plans for this site include paving the area and constructing a POL area. Construction of such a facility is likely to eliminate any early successional plant communities which may potentially exist at the site. In addition, any organisms inhabiting the site are likely to be either displaced or destroyed by construction.

Upon completion of the construction, no vegetation will be present at the site. Wildlife populations will be limited to mice, rats and other nuisance rodents which may inhabit parts of the facility. The site will be occasionally visited by passerine birds and small mammals which may occasionally cross the site. It is unlikely that the site will support a significant wildlife population based on the complete absence of wildlife habitat.

J.6.2.2 Identification of Chemicals of Potential Concern

Data used in the ecological risk assessment were evaluated as described previously in Sect. J.2.0. For the purposes of evaluating risks to terrestrial ecological receptors, COPC should be selected for surface soils (i.e., 0 to 5 ft bgs) and subsurface soils (>5 ft bgs). Organisms, especially burrowing animals, may be exposed to chemicals down to depths of five feet. Larger burrowing animals (e.g., ground squirrels) often excavate burrows which extend down to 4 ft bgs (Linsdale 1946). Contamination in subsurface soils is generally isolated, with the exception of trees which may have roots extending into the subsurface soils and migration of volatiles to the surface.

Trees do not currently exist on site and the establishment of trees at this site is unlikley since the area will be covered with asphalt in the near future. Therefore, trees are not considered a viable receptor population. Other ecological receptors are unlikely to come in direct contact with these soils. Therefore, COPC in subsurface soils would be limited to volatile organics.

Contaminants at this site are located at depths of 12 ft bgs or lower. Therefore, there are no COPC for surface soils. COPC for subsurface soils include: acetone, cis- and trans-1,2-dichloroethene, methylene chloride, tetrachloroethene, and trichloroethene.

As previously discussed, groundwater at this site does not discharge to any surface water bodies. Therefore, ecological receptors are unlikely to be exposed to COPC in groundwater. Groundwater contamination will not be addressed in this ecological risk assessment.

J.6.2.3 Exposure Pathways Identification

Exposure of ecological receptors will be limited to inhalation of volatile organics by wildlife. Burrowing mammals which inhabit the site before construction of the POL are at great potential risks as a result of organic vapors migrating into their burrow or den. Given that the Base intends to pave and build on this site. Any organisms present at the site will be displaced or destroyed.

Passerine birds and small mammals may periodically cross or visit the POL area, while traveling between destinations. Based on the amount of human activity in the area and the absence of any

wildlife habitat, it is unlikely that wildlife will spend significant amounts of time at the site. Exposures of these ecological receptors are likely to be limited to brief, sporadic exposures, which are expected to result in minimal potential exposures. In addition, the presence of an asphalt cap on the site will limit the concentration of organics in the air. Therefore exposure via inhalation of organic vapors into the atmosphere is not considered a viable exposure pathway.

J.6.3 Conclusion

Soil contamination at this site is located over 10 feet bgs. These chemicals are effectively isolated from any ecological receptors. Groundwater underlying the site does not discharge to surface waters, ecological receptors will not be exposed to chemicals in the groundwater. Ecological receptors present at the site before construction of the POL area, are likely to be displaced or destroyed by construction activities. Exposure to wildlife visiting the POL area is expected to be limited to brief, sporadic exposures to organic vapors which seep through cracks in the asphalt and are dispersed into the atmosphere. This is not considered to be a significant exposure pathway. Based on the absence of any viable potential exposure pathways for ecological receptors, potential ecological risks associated with the COPC at expected to be minimal.

J.7.0 Uncertainties

J.7.1 Introduction

The types and magnitudes of uncertainties associated with each stage of the risk assessment process play a major role in the interpretation and use of the final results of a risk assessment. Uncertainties associated with earlier stages of the process become magnified when they are associated with other uncertainties in the latter stages of the process. It is not possible to eliminate all uncertainty; however, a recognition of the uncertainties is fundamental to the understanding and use of risk assessment results. This section presents an analysis of the potential impacts of major uncertainties contributing to the overall uncertainty of the baseline risk assessment.

J.7.2 Types of Uncertainty

This section briefly introduces the evaluation of uncertainties inherent in the risk assessment process. Uncertainties can involve variations in sample analytical results, the values of variables used as input to a given model, the accuracy with which the model represents actual environmental processes, the manner in which exposure scenarios are developed, and the high-to-low dose and interspecies extrapolations for dose-response relationships. Each of these categories of potential uncertainty is discussed in this section.

Generally, risk assessments carry two types of uncertainty and each merits consideration. Measurement uncertainty refers to the usual variance that accompanies scientific measurements (e.g., instrument uncertainty associated with contaminant concentrations). The results of the risk assessment reflect the accumulated variances of the individual measured values used to develop it. A different kind of uncertainty stems from data gaps -- that is, information needed to complete the database for the assessment. Often, the data gap is significant, such as the absence of information on the effects of human exposure to a chemical or on the biological mechanism of action of an agent (EPA, 1992e).

Once the risk assessment is completed, its results must be reviewed and evaluated to identify the type and degree of uncertainty involved. The results of the evaluation should then be considered when using the risk assessment results for remedial decision making. Reliance on a simplified numerical presentation without consideration of uncertainties, limitations, and assumptions inherent in the risk assessment process can often be misleading. For example, a small impact of 10^{-6} lifetime risk of cancer may be calculated for an individual from exposure to a particular

source of contamination. However, if the uncertainty in this number is several orders of magnitude, the real risk from this source of contamination may in fact be higher than the risk from another contaminated source that has a calculated risk of 10^{-5} lifetime risk of cancer but has a small degree of uncertainty.

Alternatively, an upper bound risk of 10^{-2} lifetime risk may be calculated and appear to represent an unacceptable risk. However, the actual risk may be several orders of magnitude smaller. This situation often occurs when the estimated risk reflects limited information and large uncertainty in the calculational variables, conservative assumptions on lifestyles and land-use scenarios, and maximum or near-maximum values for almost all modeling and exposure variables to ensure that the risks are not underestimated. Although it is possible that such an exposure, dose, or sensitivity combination might occur in a given population of interest, the probability of an individual actually receiving this combination of events and conditions is usually small, and often so small that such a combination will not occur in an actual receptor population. The calculated risk for the RME individual in a Superfund risk assessment is therefore greater than the highest value of the range of actual expected risk, and not within it. Characterization of risk based on overly conservative model parameters, scenarios, and assumptions does not convey the "real world" information (EPA, 1992e) and is often misleading (if reviewed out of context). A risk estimate for an RME individual in a Superfund risk assessment has been frequently mistakenly viewed as an average risk to all individuals (EPA, 1992e).

The EPA guidance on risk assessment issued in February 1992 (EPA, 1992e) urges risk assessors to address or provide descriptions of individual risk to include the "high end" portions and "central tendency" of the risk distribution. The high end of the risk distribution is, conceptually, above the 90 percentile of the actual (either measured or estimated) distribution, but not higher than the risk to an individual in the population who has the highest risk. If only limited information on the distribution of the exposure or dose factors is available, the assessor should approach estimating the high end risk by identifying the most sensitive parameters and using maximum or near-maximum values for one or a few of these variables, leaving others at their mean values. The "central tendency" or average estimate can be derived by using average values for all exposure factors (EPA, 1992e).

J.7.3 Sources of Uncertainty

As noted previously, uncertainties are associated with the information and data used in each phase of the baseline risk assessment. These uncertainties are due to a number of factors, including the conservative bias of parameters, parameter variability (random errors or natural

variations), and the necessity of using computer models to predict complex environmental interactions. Uncertainties associated with information and data are qualitatively evaluated in this section to provide the spectrum of information needed in regard to the overall quality of the risk assessment results.

J.7.3.1 Selection of Chemicals of Concern

The criteria used for the selection of chemicals of potential concern have uncertainty associated with them. The use of blank contamination data contributes uncertainty to the analysis. Common laboratory contaminants may be excluded from the risk assessment because the associated blank samples were contaminated when these chemicals were actually present in the site-related samples. Conversely a chemical may be included in the risk assessment because its corresponding blank was "clean" when in fact the chemical was a result of laboratory contamination. Site activities and the chemicals expected to result from these activities must be considered when interpreting the results.

Eliminating chemicals which have a low frequency of detection will generally focus the assessment on the dominant chemical risks and prevent remedial decisions based on chasing "ghosts". However, in some cases, chemicals which are detected sporadically may actually be important and the sampling has missed these chemicals. The potential for this is reduced at this site by the extremely large number of environmental samples which have been analyzed.

A total of three chemicals, all phthalates were removed using this process. Removal of these chemicals from consideration reduces the potential risks associated with chemicals at the site. However, phthalates are not volatile and do not significantly migrate in groundwater, reducing their potential for migration to points of exposure. Therefore, if these chemicals are site contaminants, the potential impact upon the risk assessment is likely to be negligible.

Total petroleum hydrocarbons were selected as COPC, but this is a class of chemicals and not a single chemical with defined physicochemical properties, the potential exposure point concentrations could not be estimated using fate and transport models. This is likely to underestimate potential risks for receptors. However, the most toxic components of TPH, the PAHs, were measured separately and evaluated. Therefore, the potential increase in human health risks are likely to be negligible.

J.7.3.2 Exposure Point Concentrations

Uncertainty associated with the exposure point concentrations can be attributed to the following sources:

- Sample analytical techniques produce results that have a degree of uncertainty associated with them. These uncertainties are documented by using data qualifiers to reflect the degree of certainty of measurement. These analytical uncertainties affect the exposure point concentrations (either measured or modeled) that may be based on a particular analytical result.

- Use of the Field GC soil screening results for cis- and trans-1,2-dichloroethene, trichloroethene, and tetrachloroethene introduces uncertainty into the risk assessment. Generally, field screening data are not used, but in this instance it was felt that the screening data more accurately reflect actual concentrations than the fixed-laboratory analysis. The field screening reported concentrations exceed the fixed-laboratory reported concentrations; use of the field screening data represents the more conservative approach.

- The material in the contaminated area is heterogeneous in nature. Based on the limited number of samples, the biased nature of the sampling, and the sparse number of positive hits for any chemical of potential concern, there is considerable uncertainty in the calculation of the mean and upper bound confidence interval on the mean for the assumed sample distribution. The maximum concentration was used for both the RME and central tendency receptor. In addition, it was assumed that the maximum concentration was laterally homogeneous at the depth it was detected. This will result in an overestimation of environmental concentration at the points of exposure.

- There is uncertainty associated with the amount of dilution and reduction in groundwater concentrations as chemicals migrate from their source to a point of exposure. It was assumed that no dilution takes place. This is a conservative assumption, which will result in an overestimation of groundwater concentrations.

- When air concentrations are calculated, further uncertainty is introduced in the form of a volatilization and dilution factors that convert contaminant concentrations in soil to concentrations in air. Uncertainty is introduced when groundwater concentrations of chemicals are calculated using partition coefficients and fate and transport modeling. The Summers model used to estimate contaminant concentrations in groundwater and the air volatilization and dispersion model are discussed below.

The Summer's model is a relatively simple model designed to simulate leaching in the unsaturated zone and is considered appropriate for use to estimate leachate concentrations in groundwa-

ter. This model does not take attenuation processes such as biodegradation, first-order decay, volatilization, or other attenuation processes (other than sorption). This model is considered to be quite conservative and is likely to overestimate the concentration of contaminants in the aquifer.

The volatilization model is recommended by EPA for use at sites across the United States. The model takes into account unconsolidated soils which exist at Site 5-BCP. Default factors were used in the models which may overestimate or underestimate the actual concentrations. The use of the maximum contaminant concentration and assuming that contamination was horizontally uniform at the depth of detection will result in overestimation of interstitial vapor concentrations and an overestimation of air concentrations.

The Nearfield Box Model is a conservative model because it assumes that the dispersion of contaminants are restricted to a "box" and ignores the potential for contaminants to be transported into the atmospheres at heights which would remove the contamination from potential receptors. The overestimation of the vapor concentrations being released from soils in addition to the conservative assumptions in the model are likely to result in overestimations of the actual concentrations.

The model for estimating concentrations of contaminants in indoor air based on the migration of contaminants from soil into an overlying building was obtained from Johnson and Ettinger (1991) and is used by EPA in their Soil Screening Guidance (EPA, 1996). Most of the assumptions used in the model were taken from Johnson and Ettinger (1991). When ranges of values were given the most conservative value was selected. The defined assumptions taken from Johnson and Ettinger may either overestimate or underestimate actual values. The use of conservative assumptions from their paper is likely to overestimate potential exposure concentrations. Several conservative assumptions were used which are likely to overestimate potential indoor concentrations. It was assumed that contamination at the site was distributed evenly across the site; however, contamination is confined to isolated areas of limited size. The physical parameters for soils at the site were assumed to be uniform. This ignores the presence of the hardpan located just below the fill and the overlying compacted fill. The soil permeability of both of these soils are likely to be less than the native soil, reducing the rate of migration of contaminants. It was assumed that the building had a basement, although all of the buildings at the Base are built on slabs. Slab construction is likely to reduce the rate of diffusion of volatiles into the building, with the potential for air to be drawn into the soils adjacent to the building, as opposed to drawing only interstitial air from the underlying soils. Based on the conservative

assumptions used in this model, the concentrations of chemicals in indoor air are likely to be overestimated.

J.7.3.3 Selection of Exposure Factors

Each exposure factor selected for use in this risk assessment has some uncertainty associated with it. The scenarios chosen for the ANG risk assessments are the "most reasonable" scenarios possible at the site. The selection process is subjective and based on best professional judgement by the risk assessor. The use of a reasonable maximum exposed receptor provides a measure of the potential risk to receptors which would be representative of individuals receiving higher potential doses than the general exposed population.

J.7.3.4 Toxicity Assessment

Considerable uncertainty is associated with the qualitative (hazard assessment) and quantitative (dose-response) evaluations of a Superfund-type risk assessment. The hazard assessment deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will induce adverse effects in humans.

Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination (EPA, 1986). Positive animal cancer test data suggest that humans contain tissue(s) that may also manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncancer effects, however, positive animal data suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans (EPA, 1989c).

Uncertainty in hazard assessment arises from the nature and quality (sensitivity and selectivity) of the animal and human data. Uncertainty is decreased when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose-related; when pharmacokinetic data indicate a similar fate in animals and humans; when postulated mechanisms of toxicity are similar for humans and animals; and when the COC is structurally similar to other chemicals for which the toxicity is more completely characterized. A unique source of uncertainty in cancer hazard assessment involves the relevance of liver tumors in strains of mice with a high background incidence, especially when these tumors provide the only positive response (Scala, 1991). Many chlorinated organic chemicals in EPA cancer weight-of-evidence Group B2 fall into this category.

There are many sources of uncertainty in the dose-response evaluation for cancer (i.e., computation of a slope factor or unit risk) and noncancer effects (i.e., computation of an RfD or RfC). First is the uncertainty regarding interspecies (animal-to-human) extrapolation, which, in the absence of quantitative pharmacokinetic, dosimetric, or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Second is the uncertainty regarding intraspecies, or individual, variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so that intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity including unusual sensitivity to the COC. Even toxicity data from human occupational exposure reflect a bias because only those individuals sufficiently healthy to attend work regularly and those not unusually sensitive to the COC, are likely to be occupationally exposed. Third, uncertainty arises from the quality of the key study (from which the quantitative estimate is derived) and the database. For cancer effects, the uncertainty associated with some quality factors (e.g., group size) is expressed within the 95 percent upper bound of the slope factor. For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD or RfC to reflect poor quality of the key study or gaps in the database.

A further source of uncertainty for noncancer effects arises from use of an effect level in the estimation of an RfD or RfC, because this estimation is predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an additional uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises from estimation of an RfD or RfC for chronic exposure from less than chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less than chronic study.

As previously discussed, the extrapolation of data from laboratory results to human health RfDs has numerous sources of uncertainty associated with it. The actually toxicity may be either higher or lower, than toxicity suggested by the data. As a health protective measure, it is assumed that the toxicity is greater than the values derived from the data. Uncertainty factors are used to decrease the acceptable doses from that estimated from the available data, to acceptable doses for use in risk assessments. The use of these uncertainty factors generally result in an overestimation of potential toxicity, however, an underestimation of a chemicals toxicity may result for some chemicals.

In the absence of inhalation RfDs, oral RfDs were used as surrogate values. Exposure via and oral pathways can vary significantly in rate of absorption, mechanism of action and target organs.

Using oral RfDs for inhalation RfDs may overestimate or underestimate potential risks to human health.

Another source of uncertainty regarding quantitative risk estimation for carcinogenicity is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a nonthreshold assumption of carcinogenesis. An impressive body of evidence, however, suggests that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (Gold, et al., 1992); therefore, the use of the linearized multistage model is conservative for chemicals that exhibit a threshold for carcinogenicity. Therefore, estimated cancer risks for very low doses of carcinogens may be an overestimation of the actual risk.

J.7.3.5 Risk Characterization

Risk characterization, the process of quantifying the risk of cancer due to exposure to carcinogens, or for noncancer effects, or comparing an exposure dose with an RfD, logically combines the uncertainties of the exposure and toxicity assessments. Additional uncertainty arises from the summation of chemical- or route-specific cancer risk or HQ values to obtain a total estimate for the medium. Toxicity of a group of chemicals is generally additive only if the chemicals have the same target organ. Assuming that all chemicals affect the same target organ is a conservative assumption which is likely to overestimate potential risks. Similarly, cancer risks are generally summed for route-specific pathways, i.e. oral and inhalation risks are summed separately. Adding the ILCR for both pathways is a conservative approach which is likely to overestimate potential risks.

J.7.3.6 Ecological Risk COPC

The tools are not available, by which to determine exactly what type of habitat may exist at a site or the type of fauna present. Based on activities scheduled for the Site 5-BCP, it is unlikely that any significant habitat will be established and the frequent exposure of a significant portion of a population is unlikely. These conclusions may underestimate potential risks to ecological receptors.

This effort to identify potential uncertainties associated with each step of the risk assessment is not intended to discredit the calculated results, but to point out that risks are calculated for hypothetical receptors under a definite, strict method and to provide the reader with a qualitative evaluation of the how these uncertainties may affect the results of the risk assessment. Refine-

ments of sampling plans, analytical techniques, data statistical evaluation, exposure assessment models and parameters, hazard evaluation, dose-response assessment and risk characterization could reduce these uncertainties.

J.8.0 Summary and Conclusions

J.8.1 Summary

Soil and groundwater were evaluated at Site 5-BCP - Base Collection Pond. In addition, groundwater entering and leaving the Base was evaluated to determine the contaminant contribution (if any) by the Base as a whole.

COPC were selected in soil and groundwater for Site 5-BCP and for groundwater upgradient and downgradient of the Base. Selection of COPC was based on the criteria described in Section J.2.0. COPC evaluated in the risk assessment for soil and groundwater in different sites were as follows:

- Soil
  - Site 5-BCP - polyaromatic hydrocarbons (PAH), TPH, bis(2-ethylbenzyl)-phthalate, diethylphthalate, acetone, and methylene chloride.

- Groundwater
  - Site 5-BCP - tetrachloroethene; trichloroethene from regional contamination.
  - Upgradient perimeter Wells; trichloroethene, 1,2-dichloropropane, carbon tetra-chloride, diethylphthalate, and di-n-butyl phthalate.
  - Downgradient perimeter wells; tetrachloroethene, trichloroethene, 1,2-dichloro-propane, chrysene, cis-1,2-dichloroethene, and bis-(2-ethylhexyl)phthalate.

A site conceptual model (Figure J-3) was created to illustrate the mechanisms of exposure to potential receptors. RME were evaluated for all exposure pathways. CT exposure scenarios were evaluated for those pathways where the RME risk estimates were above the acceptable limit as mandated by the EPA. Exposure pathways considered for these scenarios were as follows:

- Soil
  - Inhalation of volatiles

- Groundwater
  - Ingestion
  - Dermal contact during household use
  - Inhalation of volatiles during household use

Potential receptors that were evaluated were the future resident near the Base, a construction worker on Base, Base employees working outdoors at Site 5-BCP, and within a hypothetical building constructed at Site 5-BCP.

Risk assessment results are presented in Tables J-5-1 to J-5-10. Significant chemicals, pathways, and corresponding risks for groundwater are summarized in Tables J-8-1 and J-8-2.

J.8.2 Conclusions

Risks from exposure to soil at Site 5-BCP for construction activities and Base operations are below the target risk range mandated by the EPA.

Groundwater at the Base is contaminated by organic constituents. Primary contributors to cancer risk are trichloroethene and tetrachloroethene. Based on the comparison of risks from upgradient and downgradient Base perimeter wells, it may be concluded that tetrachloroethene is the only significant contaminant in groundwater derived from ANG activities. The total risk from downgradient Base perimeter wells is less than the total risk from upgradient Base perimeter wells.

Exposure of ecological receptors at Site 5-BCP is limited to inhalation of volatile organics migrating to the surface from subsurface soils. Based on the poor habitat present at the site and the future construction which is likely to remove all potential wildlife habitat, potential exposure of ecological receptors is expected to be minimal. With the absence of any viable potential exposure pathways, ecological receptors are not likely to be adversely affected by contaminants associated with Site 5-BCP or the Base.

J.9.0 References

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Table J-2-1

Soil Sample Analysis Summary
California Air National Guard - Fresno, California

Site ID	Number of Soil Borings	Number of Soil Samples	Number of Field Duplicates	Depth of Range of Samples (ft)	Analytical Parameters
Site 5	10	37	4	9-86	VOCs Semivolatiles TPH (as diesel)
Site 5 Surface Soil Samples	4	8	1	0-3	VOCs Semivolatiles TPH (as diesel) Pesticides/PCBs TCLP Metals[b] Total Organic Lead[b]
Site 5 Soil Screening Samples	12	165	0	5-87	VOCs
Base Background	1	8	1	3-65	VOCs Semivolatiles TPH (as diesel) Pesticides/PCBs RCRA Metals TCLP Metals[b] Total Organic Lead[b]

[a]VOCs - volatile organic compounds
TPH - total petroleum hydrocarbons
BTEX - benzene, toluene, ethyl benzene, xylenes
PCB - polychlorinated biphenyls
RCRA - Resource Conservation and Recovery Act
TCLP - Toxicity Characteristic Leaching Procedure
[b]Data not considered in risk assessment.

Table J-2-2

Groundwater Sample Analysis Summary
California Air National Guard - Fresno, California

Site of Area ID	Number of Monitoring Wells	Number of Sample Rounds	Number of Field Duplicates	Number of Groundwater Samples per Parameter[a]					
				VOCs	Semivolatiles	TPH (as diesel)	Pesticides/ PCBs	Metals	Total Lead
Base Background									
BMW-1	1	2	0	2	2	2	2	2	0
BMW-2	1	5	1	5	2	5	2	2	0
Total	**2**	**7**	**1**	**7**	**4**	**7**	**4**	**4**	**0**
Base Perimeter, Upgradient									
MWBP-01,-02, -03,-04	4	6	4	24	12	0	12	0	0
MWBP -09,-10	2	3	1	6	2	0	2	0	0
Total	**6**	**9**	**5**	**30**	**14**	**0**	**14**	**0**	**0**
Base Perimeter, Downgradient									
MWBP -05, -06A,-07,-08	4	6	2	24	12	0	12	0	0
MWBP -11,-12	2	3	1	6	2	0	2	0	0
Total	**6**	**9**	**3**	**30**	**14**	**0**	**14**	**0**	**0**

Table J-2-3

Chemical of Potential Concern Selection Results
California Air National Guard - Fresno, California

(Page 1 of 3)

Chemical	Range of Detections[a,b]	COPC Selection	Reason for Rejection	Source Concentration for Risk Assessment[a,c]	Source Concentration for Groundwater Modeling
Site 5 Soils					
Acetone	24-550	Yes		24	550
Benzo(b)fluoranthene	130	Yes		130	130
Benzo(k)fluoranthene	130	Yes		130	130
Benzo(a)pyrene	100	Yes		100	100
bis(2-Ethylhexyl)phthalate	41-6200	Yes		140	6200
Chrysene	110	Yes		110	110
Di-n-butyl phthalate	47	No	Single hit, common laboratory contaminant	NA	NA
cis-1,2-Dichloroethene	NA	Yes		NA[d]	66[f]
trans1,2-Dichloroethene	NA	Yes		NA[d]	111[f]
Diethyl phthalate	59-1400	Yes		59	1400
Fluoranthene	97-130	Yes		130	130
Indeno(1,2,3-cd)pyrene	40-82	Yes		82	82
Methylene chloride	10-85	Yes		10	85
Phenanthrene	52	Yes		52	52

Table J-2-3

Chemical of Potential Concern Selection Results
California Air National Guard - Fresno, California

Chemical	Range of Detections[a,b]	COPC Selection	Reason for Rejection	Source Concentration for Risk Assessment[a,c]	Source Concentration for Groundwater Modeling
Pyrene	50-130	Yes		130	130
Tetrachloroethene	NA	Yes		NA[d]	640[f]
Total petroleum hydrocarbons (TPH)	20000-28000	Yes		28000	NA[e]
Site 5 Groundwater: Wells MW5-01, -02					
Tetrachloroethene	3.1-26	Yes		26	NA
Trichloroethene	8.7-19	Yes		19	NA
Upgradient Base Perimeter Groundwater: Wells MWBP-01, -02, -03, -04, -09, -10					
bis(2-Ethylhexyl)phthalate	0.5	No	Single hit, estimated concentration below detection limit	NA	NA
Carbon tetrachloride	0.6-0.8	Yes		0.8	NA
1,2-Dichloropropane	1.1-13	Yes		13	NA
Di-n-butyl phthalate	0.9-2	Yes		2	NA
Diethyl phthalate	0.7-2	Yes		2	NA
Trichloroethene	2-520	Yes		520	NA
Downgradient Base Perimeter Groundwater: Wells MWBP-05, -06A, -07, -08, -11, -12					

Table J-2-3

Chemical of Potential Concern Selection Results
California Air National Guard - Fresno, California

Chemical	Range of Detections[a,b]	COPC Selection	Reason for Rejection	Source Concentration for Risk Assessment[a,c]	Source Concentration for Groundwater Modeling
bis(2-Ethylhexyl)phthalate	0.5-7	Yes		7	NA
Chrysene	3-6	Yes		6	NA
Di-n-butyl phthalate	0.5	No	Single hit, estimated concentration below detection limit	NA	NA
cis-1,2-Dichloroethene	13	Yes		13	NA
1,2-Dichloropropane	0.5-4.1	Yes		4.1	NA
Tetrachloroethene	1-110	Yes		110	NA
Trichloroethene	0.7-41	Yes		41	NA

[a] Units = µg/kg for soil, µg/L for groundwater.
[b] Excluding data rejected during validation and blank correction.
[c] For soil, maximum concentration in the first three feet below ground surface.
[d] No data ≤ 3 ft. bgs.
[e] TPH consists of several individual constituents, each with its own fate and transport characteristics; therefore, groundwater modeling cannot be performed with TPH.
[f] Maximum concentration from field screening.

ft = feet, bgs = below ground surface, NA = not applicable

Table J-3-1

Exposure Concentrations of Contaminants in Outdoor Air for On-Site Receptors California Air National Guard - Fresno, California

Contaminant	Vapor[a] Pressure (mm Hg)	Molecular[a] Weight (g)	Air Diffusion[a] Coefficient (cm2/sec)	Maximum Soil Concentration (µg/kg)	Depth to Detection (ft)	Saturated Vapor[b] Concentration (g/cm3)	Construction Worker		Base Employee	
							Contaminant[c] Emission Rate (g/sec)	Contaminant Air Concentration (mg/m3)	Contaminant Emission Rate (g/sec)	Contaminant Air Concentration (mg/m3)
Acetone	231	58.1	0.124	24	0	6.76E-04	1.38E-07	1.29E-08	2.30E-08	2.15E-09
cis-1,2-Dichloroethene	200	96.9	0.0736	66	35	9.77E-04	1.76E-08	1.64E-09	1.38E-08	1.29E-09
Methylene Chloride	434.9	84.9	0.101	10	0	1.86E-03	1.29E-07	1.20E-08	2.14E-08	2.01E-09
Tetrachloroethene	18.49	165.8	0.072	329	10	1.55E-04	4.18E-08	3.91E-09	2.28E-08	2.13E-09
trans-1,2-Dichloroethene	340	96.9	0.0707	111	65	1.66E-03	2.66E-08	2.49E-09	2.32E-08	2.17E-09
Trichloroethene	69	131.4	0.079	254	10	4.57E-04	1.05E-07	9.79E-09	5.71E-08	5.34E-09

[a] EPA, 1996.
[b] Equation 3-2.
[c] Equation 3-1.
[d] Equation 3-3.

Table J-3-2

Input Parameters Used in Modeling the Indoor Air Concentrations California Air National Guard - Fresno, California

Parameter	Value	Reference
Area of basement	2.09×10^7 cm^2	Typical building are connecting Site 5.
Building height	6m	Assumption
Depth of basement	1m	Assumption
Building ventilation rate	1.74×10^6 cm^3/5	Assumed 0.5 building volume/h Johnson & Ettinger, 1991
Thickness of building foundation	15 cm	Johnson & Ettinger, 1991
Ratio at the crack area to area of the basement	0.001	Johnson & Ettinger, 1991
Length of hypothetical cylinder used to estimate vapor flow into the basement of the hypothetical building	1.83×10^4cm	Length is equal to the total floor/ wall seam perimeter distance
Soil dry bulk density	1.81 g/cm^3	Measured value
Soil particulate density	1.3 g/cm^3	Measured value
Soil moisture content	0.162 cm^3/g	Measured value
Soil porosity	0.51	Measured value
Soil air-filled porosity	0.217	Calculated, Equation 3-7
Soil water-filled porosity	0.293	Measured value
Soil permeability	9×10^{-9}cm^2	Johnson & Ettinger, 1991
Vapor viscosity	1.8×10^{-4} g/cm-s^2	Johnson & Ettinger, 1991
Change vapor pressure between building and soil	10 g/cm-s^2	Johnson & Ettinger, 1991

Table J-3-3

Exposure Concentrations of Contaminants in Indoor Air for On-Site Receptors
California Air National Guard - Fresno, California

Contaminant	Maximum Contaminant Concentration (g/g)	Source Vapor[a] Concentration (g/cm3)	Depth to Detection (ft)	Diffusion[b] Coefficient (cm2/sec)	Contaminant[b] Concentration in Building (mg/m3)
Acetone	6.60E-08	3.2228E-08	35	7.36E-02	5.14E-05
cis-1,2-Dichloroethene	3.29E-07	1.30403E-07	10	7.20E-02	2.17E-04
Methylene Chloride	1.00E-08	3.82526E-09	0	1.01E-01	8.57E-06
Tetrachloroethene	2.54E-07	1.46323E-07	10	7.90E-02	6.19E-07
trans-1,2-Dichloroethene	1.11E-07	8.75519E-08	65	7.07E-02	1.26E-04
Trichloroethene	2.40E-08	2.32413E-10	0	1.24E-01	6.19E-07

[a] Equation 3-6.
[b] Equation 3-9.
[c] Equation 3-12.

Table J-3-4

Chemical Parameters Used to Calculate K_d and Calculated K_d Values California Air National Guard - Fresno, California

Chemical	K_{ow} [a]	K_{oc}	K_d (L/kg)
Acetone	0.57	0.36	2.0×10^{-3}
Benzene	135[b]	85	0.47
Benzo(b)fluoranthene	$3.72 \times 10^{+6}$	$2.34 \times 10^{+6}$	$1.29 \times 10^{+4}$
Benzo(k)fluoranthene	$6.92 \times 10^{+6}$	$4.36 \times 10^{+6}$	$2.40 \times 10^{+4}$
Benzo(a)pyrene	$9.55 \times 10^{+5}$	$6.02 \times 10^{+5}$	$3.31 \times 10^{+3}$
2-Butanone	1.81[b]	1.14	6.27×10^{-3}
Chrysene	$4.00 \times 10^{+5}$ [b]	$2.52 \times 10^{+5}$	$1.39 \times 10^{+3}$
cis-1,2-Dichloroethene	48[c]	29[c]	0.16
Diethylphthalate	912	575	3.16
Ethyl Benzene	1400 [b]	882	4.9
bis(2-Ethylhexyl)phthtalate	$2.00 \times 10^{+5}$	$1.26 \times 10^{+5}$	693
Fluoranthene	$2.14 \times 10^{+5}$	$1.35 \times 10^{+5}$	742
2-Hexanone	24	15.1	0.08
Indeno(1,2,3-cd)pyrene	$4.57 \times 10^{+7}$	$2.88 \times 10^{+7}$	$1.58 \times 10^{+5}$
4-Methyl-2-Pentanone	12.3	7.75	0.043
Methylene Chloride	17.8 [b]	11.2	0.062
Phenanthrene	$2.90 \times 10^{+4}$	$1.83 \times 10^{+4}$	100
Pyrene	$1.51 \times 10^{+5}$	$9.51 \times 10^{+4}$	523
Tetrachloroethene	357[c]	300[c]	1.65
Toluene	490	309	1.7
Total Petroleum Hydrocarbons	--	--	--
trans-1,2-Dichloroetnene	96[c]	50[c]	0.28
Trichloroethene	271[c]	94[c]	0.52
Xylenes	1100	693	3.8

[a]EPA, RREL, unless otherwise indicated.
[b]EPA, 1992f.
[c]EPA, 1994c.

K_{ow} - Octanol/Water Partitioning Coefficient
K_{oc} - Organic Carbon/Water Partitioning Coefficient
K_d - Water/Soil Partitioning Coefficient

Table J-3-5

Modeled Concentrations for COPCs in Groundwater
California Air National Guard - Fresno, California

Chemical	Cs[a] (µg/kg)	Cp[b] (µg/L)	Cgw[c] (µg/L)
Site 5 - Base Collection Pond			
Acetone	550	$2.8 \times 10^{+5}$	2.30
Benzo(b)fluoranthene	130	0.01	8.4×10^{-8}
Benzo(k)fluoranthene	130	0.0054	4.5×10^{-8}
Benzo(a)pyrene	100	0.03	2.5×10^{-7}
Chrysene	110	0.079	6.7×10^{-7}
Diethylphthalate	1400	443	0.0037
bis(2-Ethylhexyl)phthalate	6200	8.95	7.47×10^{-5}
Fluoranthene	130	0.18	1.5×10^{-6}
Indeno(1,2,3-cd) pyrene	82	5.2×10^{-4}	4.3×10^{-9}
Methylene Chloride	85	$1.42 \times 10^{+3}$	1.18×10^{-2}
Phenanthrene	52	0.52	4.3×10^{-6}
Pyrene	130	0.25	2.1×10^{-6}
cis-1,2-Dichloroethene	66[d]	414	3.5×10^{-3}
trans-1,2-Dichloroethene	111[d]	404	3.4×10^{-3}
Trichloroethene	410[d]	793	6.6×10^{-3}
Tetrachloroethene	640[d]	388	3.2×10^{-3}

[a]Concentration in soil. Value in table represents the highest reported concentration in soil samples from fixed-base laboratory, unless otherwise noted.
[b]Concentration in leachate using Summers Model (Eq. 3-2).
[c]Concentration in groundwater using Summers Model (Eq. 3-1).
[d]Maximum concentrations from field screening results.

Table J-3-6

Exposure Concentrations of Contaminants in Groundwater and Indoor Air From Groundwater California Air National Guard - Fresno, California

Site	Chemical	Groundwater Concentration (µg/L)	Indoor Air Concentration (mg/m^3)
Site 5 - Measured Concentrations	Tetrachloroethene	2.60E+01	1.30E-02
	Trichloroethene	1.90E+01	9.50E-03
Site 5 - Modeled Concentrations	Acetone	2.30E+00	1.15E-03
	Benzo(b)fluoranthene	8.40E-08	NA
	Benzo(k)fluoranthene	4.50E-08	NA
	Benzo(a)pyrene	2.50E-07	NA
	bis(2-ethylhexyl) phthalate	7.47E-05	NA
	Chyrsene	6.70E-07	NA
	cis-1,2-Dichloroethene	3.50E-03	1.75E-06
	Diethylphthalate	3.70E-03	NA
	Fluoranthene	1.50E-06	NA
	Indeno(1,2,3-cd)pyrene	4.30E-09	NA
	Methylene Chloride	1.18E-02	5.90E-06
	Phenanthrene	4.30E-06	NA
	Pyrene	2.10E-06	NA
	Tetrachloroethene	3.20E-03	1.60E-06
	trans-1,2-Dichloroethene	3.40E-03	1.70E-06
	Trichloroethene	6.60E-03	3.30E-06
Upgradient Monitoring Wells	1,2-dichloropropane	1.30E+01	6.50E-03
	Carbon Tetrachloride	8.00E-01	4.00E-04
	Di-n-butyl phthalate	2.00E+00	0.00E+00
	Diethylphthalate	2.00E+00	0.00E+00
	Trichloroethene	5.20E+02	2.60E-01
Downgradient Monitoring Wells	1,2-Dichloropropane	4.10E+00	2.05E-03
	bis(2-ethylhexyl)phthalate	7.00E+00	0.00E+00
	Chrysene	6.00E+00	0.00E+00
	cis-1,2-dichloroethene	1.30E+01	6.50E-03
	Tetrachloroethene	1.10E+02	5.50E-02
	Trichloroethene	4.10E+01	2.05E-02

NA = Not applicable

Table J-3-7

Exposure Parameters and Assumptions, Inhalation of Volatile Emissions from Soil for On-Site Receptors California Air National Guard - Fresno, California

		Parameter Value
Parameter	Receptor	Reasonable Maximum Exposure
CS, Chemical Concentration in Soil	All receptors	UCL[a]
CA, Chemical Concentration in Air	All Receptors	UCL[b]
IhR, Inhalation Rate	All Receptors	20 m^3/day[c]
EF, Exposure Frequency	Base Worker[d] Construction Worker	250 days/year[e] 250 days/year[e]
ED, Exposure Duration	Base Worker Construction	25 years[f] 1 year[g]
BW, Body Weight	Worker	70 kg[h]
AT, Averaging Time	All Receptors	
carcinogens		25,550 days[i]
noncarcinogens		9,125 days[j]
noncarcinogens	All Receptors Base Worker Construction Worker	365 days[j]

References:

- a Upper 95 percent confidence interval (UCL) calculated from site characterization data; EPA Region IX, 1989.
- b Upper 95 percent confidence interval (UCL) calculated from site characterization data and/or modeling; EPA Region IX, 1989.
- c Reasonable upper-bound for adults in residential or occupationals setting; EPA, 1991a, EPA Region IX, 1989.
- d Base worker is representative of a person working either outdoors or within a building.
- e 5 days/week, 50 working weeks/year; EPA, 1991a.
- f Median tenure for 16 years old and older; Bureau of the Census, 1990.
- g Length of time for average construction project.
- h Average adult body weight; EPA, 1989b.
- i 70 years x 365 days/year.
- j ED x 365 days/year.

Table J-3-8

Parameters for Evaluating Exposure via Dermal Contact
California Air National Guard - Fresno, California

Chemical	PC (cm/hr)	ABS[a]	GAF[b]
Acetone	0.0014	0.0005[c]	0.83[c]
Benzo(b)fluoranthene	1.2	NA	0.5
Benzo(k)fluoranthene	4	NA	0.5
Benzo(a)pyrene	1.2	NA	0.5
Carbon tetrachloride	0.022	0.3	0.9
Chrysene	0.81	NA	0.5
cis-1,2-Dichloroethene	0.0015	0.3	0.9
1,2-Dichloropropane	0.01	0.3	0.9
Diethyl phthalate	0.0048	0.3	0.9
Di-n-butyl phthalate	0.19	0.3	0.85[d]
bis(2-Ethylhexyl)phthalate	0.046	0.004[c]	0.9[e]
Fluoranthene	0.36	0.3	0.9
Indeno(1,2,3-cd)pyrene	1.9	NA	0.5
Methylene Chloride	0.0045	0.3	1.0[d]
Phenanthrene	0.27	0.3	0.9
Pyrene	0.53	0.3	0.9
Tetrachloroethene	0.048	0.3	0.9
trans-1,2-Dichloroethene	0.013	0.3	0.9
Trichloroethene	0.016	0.3	0.9

[a] EPA, 1993a.
[b] Default (see explanation in Section 4.3).
[c] EPA, 1993b.
[d] Jones & Owen, 1989.
[e] SRC, 1991.
ND - No data; NA - not applicable.

Table J-3-9

Exposure Parameters and Assumptions, Dermal Contact with Chemicals in Water Fresno Air National Guard - Fresno, California

Parameter	Receptor	Parameter Value Central Tendency	 Reasonable Maximum Exposure
CW, Chemical Concentration in Water (mg/L)	All receptors	UCL[a]	UCL[a]
SA, Surface Area	Adult Resident	18,150 cm^2 [b]	18,150 cm^2 [b]
	Child Resident	7,200 cm^2 [c]	7,200 cm^2 [c]
PC, Dermal Permeability Constant	All Receptors	Chemical-specific;	(Table J-3-6)
ET, Exposure Time	Adult Resident		0.2 hours/day[d]
	Child Resident	0.12 hours/day[d]	0.14 hours/day[d]
		0.14 hours/day[d]	
EF, Exposure Frequency	Adult Resident		350 days/year[e]
	Child Resident	350 days/year[e]	350 days/year[e]
		350 days/year[e]	
ED, Exposure Duration	Adult Resident		30 years[g]
	Child Resident	9 years[f]	6 years[h]
		6 years[h]	
CF, Volumetric Conversion Factor for Water	All Receptors		10^{-3} L/cm^3
		10^{-3} L/cm^3	
BW, Body Weight	Adult Resident		70 kg[i]
	Child Resident	70 kg[i]	15 kg[j]
AT, Averaging Time		15 kg[j]	
carcinogens	Adult Resident		25,550 days[k]
noncarcinogens	Adult Resident	25,550 days[k]	10,950 days[l]
noncarcinogens	Child Resident	3,285 days[l]	2,190 days[l]
		2,190 days[l]	

References:

- [a] Upper 95 percent confidence interval (UCL) calculated from site characterization data; EPA Region IX, 1989.
- [b] 50th percentile adult body surface area (male and female averaged); EPA, 1992a.
- [c] EPA, 1992a.
- [d] 50th and 90th percentile values; EPA, 1989a (RAGS).
- [e] based on 50 weeks at home and 2 weeks on vacation; EPA, 1991a.
- [f] 50th percentile at one residence; EPA, 1989b.
- [g] 90th percentile at one residence; EPA, 1991a.
- [h] Child resident age 0-6 years, EPA, 1991a.
- [i] Average adult body weight, EPA 1989b.
- [j] Average body weight for child 0-6 years, DTSC, 1990.
- [k] 70 years x 365 days/year.
- [l] ED x 365 days/year.

Table J-3-10

Exposure Parameters and Assumptions, Ingestion of Chemicals in Drinking Water California Air National Guard - Fresno, California

Parameter	Receptor	Parameter Value: Central Tendency	Parameter Value: Reasonable Maximum Exposure
CW, Chemical Concentration in Water (mg/L)	All receptors	UCL[a]	UCL[a]
IR, Ingestion Rate	Adult Resident	2 L/day[b]	2 L/day[b]
	Child Resident	1L/day[b]	1L/day[b]
DF, Diet Fraction	Adult Resident	0.75[c]	1.0[c]
	Child Resident	0.75[c]	1.0[c]
EF, Exposure Frequency	All Receptors	350 days/year[d]	350 days/year[d]
ED, Exposure Duration	Adult Resident	9 years[e]	30 years[f]
	Child Resident	6 years[g]	6 years[g]
BW, Body Weight	Adult Resident	70 kg[h]	70 kg[h]
	Child Resident	15 kg[i]	15 kg[i]
AT, Averaging Time			
carcinogens	Adult Resident	25,550 days[j]	25,550 days[j]
noncarcinogens	Adult Resident	3,285 days[k]	10,950 days[k]
noncarcinogens	Child Resident	2,190 days[k]	2,190 days[k]

References:

- [a] Upper 95 percent confidence interval (UCL) calculated from site characterization data: EPA Region IX, 1989.
- [b] 90th percentile for drinking water ingestion; EPA, 1991a, EPA Region IX, 1989
- [c] EPA, 1989b
- [d] based on 50 weeks at home and 2 weeks on vacation; EPA, 1991a
- [e] 50th percentile at one residence; EPA, 1989b
- [f] 90th percentile at one residence; EPA, 1991a
- [g] child resident age 0-6 years; DTSC, 1994
- [h] average adult body weight; EPA, 1989b
- [i] average body weight for child age 0-6; EPA, 1991a
- [j] 70 years x 365 days/year; EPA, 1991a
- [k] ED x 365 days/year; EPA, 1991a

Table J-3-11

Exposure Parameters and Assumptions, Inhalation of Volatile from Household Water Use California Air National Guard - Fresno, California

Parameter	Receptor[a]	Parameter Value: Central Tendency	Parameter Value: Reasonable Maximum Exposure
CW, Chemical Concentration in Water (mg/L)		UCL[b]	UCL[b]
CA, Chemical Concentration in Air (mg/m^3)		UCL[c]	UCL[c]
IhR, Inhalation Rate	Adult Resident	10.3 m^3/day[d]	15 m^3/day[e]
ET, Exposure Time	Adult Resident	16.4 hours/day[f]	16.4 hours/day[f]
EF, Exposure Frequency	Adult Resident	350 days/year[g]	350 days/year[g]
ED, Exposure Duration	Adult Resident	9 years[h]	30 years[i]
BW, Body Weight	Adult Resident	70 kg[j]	70 kg[j]
AT, Averaging Time			
carcinogens	Adult Resident	25,550 days[k]	25,550 days[k]
noncarcinogens	Adult Resident	3,285 days[l]	10,950 days[l]

References:

- a Intake from inhalation of VOCs by child resident is assumed to be equal to the equivalent to the amount of ingested water; DTSC, 1994
- b Upper 95 percent confidence interval (UCL) calculated from site characterization data and/or modeling; EPA Region IX, 1989.
- c To be determined from VOC model presented in Appendix A and C_w
- d Average for time spent indoors assuming on hourly inhalation rate of 0.63 m^3 for 16.4 hours/day; EPA, 1989b
- e Reasonable upper-bound for daily indoor residential activities; EPA, 1991a
- f Time the average adult spends inside the home; EPA, 1989b
- g Based on 50 weeks at home and 2 weeks on vacation; EPA, 1991a
- h 50th percentile at one residence; EPA, 1989b
- i 90th percentile at one residence; EPA, 1991a
- j Average adult body weight; EPA, 1989b
- k 70 years x 365 days/year
- l ED x 365 days/year

Table J-4-1

Carcinogenic Evaluation of the COPCs
California Air National Guard - Fresno, California

Chemical	EPA Group	Inhalation SF $(mg/kg\text{-}day)^{-1}$	Oral SF $(mg/kg\text{-}day)^{-1}$	Dermal SF[a] $(mg/kg\text{-}day)^{-1}$
Acetone	D[b]	ND	ND	ND
Benzo(b)fluoranthene	B2[b]	0.39	1.2	NA
Benzo(k)fluoranthene	B2[b]	0.39	1.2	NA
Benzo(a)pyrene	B2[b]	3.9	12	NA
bis(2-Ethylhexyl)phthalate	B2[b]	0.0084	0.0084	0.016
Carbon tetrachloride	B2[b]	0.15[d]	0.15[d]	0.17
Chrysene	B2[b]	0.039	0.12	NA
Di-n-butyl phthalate	D[b]	ND	ND	ND
cis-1,2-Dichloroethene	D[b]	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND	ND
1,2-Dichloropropane	BC[2]	0.063	0.063	0.076
Diethyl phthalate	D[b]	ND	ND	ND
Fluoranthene	D[b]	ND	ND	ND
Indeno(1,2,3-cd)pyrene	B2[b]	0.39	1.2	NA
Methylene chloride (dichloromethane)	B2[b]	0.0035[b]	0.014[b]	0.0075
Phenanthrene	D[b]	ND	ND	ND
Pyrene	D[b]	ND	ND	ND
Tetrachloroethene (Perchloroethylene)	C-B2[d]	0.021	0.052	0.058
Trichloroethene	C-B2[d]	0.01	0.015	0.011

[a] Derived by dividing the oral SF by the GAF (Table J-3-6).
[b] IRIS (EPA, 1994b).
[c] HEAST (EPA, 1993c).
[d] California EPA, 1994.

ND = not determined.
NA = not applicable; oral exposure is not an appropriate model for the dermal effects of the PAHs.

Table J-4-2

Noncancer Evaluation of the COPCs
California Air National Guard - Fresno, California

Chemical	Oral RfD (mg/kg-day)	Inhalation RfD[a] (mg/kg-day)	Dermal RfD[b] (mg/kg-day)
Acetone	0.1[c]	0.1[d]	0.83
Benzo(b)fluoranthene	0.3	NA	ND
Benzo(k)fluoranthene	0.3	NA	ND
Benzo(a)pyrene	0.3	NA	ND
bis(2-Ethylhexyl)phthalate	0.02[c]	NA	0.018
Carbon tetrachloride	0.0007[c]	0.00057[d]	0.00063
Chyrsene	0.3	NA	ND
Di-n-butyl phthalate	0.1[c]	NA	0.085
cis-1,2-Dichloroethene	0.01[e]	0.01[d]	0.009
trans-1,2-Dichloroethene	0.02[c]	0.02[d]	0.018
1,2-Dichloropropane	ND	0.0011[c]	ND
Diethyl phthalate	0.8[c]	NA	0.72
Fluoranthene	0.04[c]	0.04[d]	0.036
Indeno(1,2,3-cd)pyrene	0.03	0.03[d]	ND
Methylene chloride (dichloromethane)	0.06[c]	0.86[e]	0.06
Phenanthrene	0.3	NA	ND
Pyrene	0.03[c]	NA	0.027
Tetrachloroethene (Perchloroethylene)	0.01[c]	0.01[d]	0.009
Trichloroethene	0.006[d]	0.006[d]	0.006[d]

[a] Estimated from the inhalation reference concentration, when necessary, by assuming humans weigh 70 kg and inhale 20 m^3/day.
[b] Derived by multiplying the oral RfD by the GAF (Table J-3-6).
[c] IRIS (EPA, 1994b).
[d] Oral RfD used in absence of inhalation RfC or RfD.
[e] HEAST (EPA, 1993c).
[f] EPA, 1995.

ND = not determined.
NA = not applicable.

Table J-5-1

Summary of Potential Risks for On-Site Workers
California Air National Guard - Fresno, California

Chemical	Air Concentration (mg/m3)	Inhalation Reference Dose (mg/kg-d)	Inhalation Cancer Slope Factor (1/[mg/kg-d])	Noncancer Intake (mg/kg-day)	Cancer Intake (mg/kg-day)	Hazard Index	Incremental Lifetime Cancer Risk
Construction Worker							
Acetone	1.29E-08	1.00E-01	ND	2.52E-09	3.61E-11	2.52E-08	NA
cis-1,2-Dichloroethene	1.64E-09	1.00E-02	ND	3.22E-10	4.59E-12	3.22E-08	NA
Methylene Chloride	1.20E-08	8.60E-01	3.50E-03	2.36E-09	3.37E-11	2.74E-09	1.18E-13
Tetrachloroethene	3.91E-09	1.00E-02	2.10E-02	7.65E-10	1.09E-11	7.65E-08	2.30E-13
trans-1,2-Dichloroethene	2.49E-09	2.00E-02	ND	4.88E-10	6.97E-12	2.44E-08	NA
Trichloroethene	9.79E-09	6.00E-03	1.00E-02	1.92E-09	2.73795E-11	3.19E-07	2.74E-13
SUM						**4.80E-07**	**6.21E-13**
Base Personnel - Outdoor							
Acetone	2.15E-09	1.00E-01	ND	4.21E-10	1.50E-10	4.21E-09	NA
cis-1,2-Dichloroethene	1.29E-09	1.00E-02	ND	2.53E-10	9.04E-11	2.53E-08	NA
Methylene Chloride	2.01E-09	8.60E-01	3.50E-03	3.93E-10	1.40E-10	4.57E-10	4.91E-13
Tetrachloroethene	2.13E-09	1.00E-02	2.10E-02	4.17E-10	1.49E-10	4.17E-08	3.13E-12
trans-1,2-Dichloroethene	2.17E-09	2.00E-02	ND	4.24E-10	1.52E-10	2.12E-08	NA
Trichloroethene	5.34E-09	6.00E-03	1.00E-02	1.05E-09	3.73E-10	1.74E-07	3.73E-12
SUM						**2.67E-07**	**7.35E-12**
Base Personnel - Indoor							
Acetone	6.19E-07	1.00E-01	ND	1.21E-07	4.33E-08	1.21E-06	NA
cis-1,2-Dichloroethene	5.14E-05	1.00E-02	ND	1.01E-05	3.60E-06	1.01E-03	NA
Methylene Chloride	8.57E-06	8.60E-01	3.50E-03	1.68E-06	5.99E-07	1.95E-06	2.10E-09
Tetrachloroethene	2.17E-04	1.00E-02	2.10E-02	4.25E-05	1.52E-05	4.25E-03	3.19E-07
trans-1,2-Dichloroethene	1.26E-04	2.00E-02	ND	2.48E-05	8.84E-06	1.24E-03	NA
Trichloroethene	6.19E-07	6.00E-03	1.00E-02	1.21E-07	4.33E-08	2.02E-05	4.33E-10
SUM						**6.52E-03**	**3.21E-07**
Base Personnel (Indoor+Outdoor)						**6.52E-03**	**3.21E-07**

NA - Not applicable

Table J-5-2

Potential Risks for Adult RME Residential Exposure Scenario
Dermal Exposure
California Air National Guard - Fresno, California

Site or Location	Chemical	Groundwater Concentration (ug/L)	Dermal RfD (mg/kg-day)	Dermal Cancer Slope Factor (1[mg/kg-day])	Noncarcinogenic Intake (mg/kg-day)	Carcinogenic Intake (mg/kg-day)	Hazard Index	Incremental Lifetime Cancer Risk
Site 5 - Measured Concentrations	Tetrachloroethene	2.60E+01	9.00E-03	5.67E-02	6.21E-05	2.66E-05	6.9E-03	1.5E-06
	Trichloroethene	1.90E+01	5.40E-03	1.67E-02	1.51E-05	6.48E-06	2.8E-03	1.1E-07
	SUM			ND			**9.7E-03**	**1.6E-06**
Site 5 - Modeled Concentrations	Acetone	2.30E+00	8.30E-02	ND	1.60E-07	ND	1.9E-06	NA
	Benzo(a)pyrene	2.50E-07	ND	2.40E+01	ND	6.39E-12	NA	1.5E-10
	Benzo(b)fluoranthene	8.40E-08	ND	2.40E+00	ND	2.15E-12	NA	5.2E-12
	Benzo(k)fluoranthene	4.50E-08	ND	2.40E+00	ND	3.84E-12	NA	9.2E-12
	bis(2-ethylhexyl)phthalate	7.47E-05	1.80E-02	9.33E-03	1.71E-10	7.32E-11	9.5E-09	6.8E-13
	Chrysene	6.70E-07	ND	2.40E-01	ND	1.16E-11	NA	2.8E-12
	cis-1,2-Dichloroethene	3.46E-03	9.00E-03	ND	2.58E-10	ND	2.9E-08	NA
	Diethylphthalate	3.70E-03	7.20E-01	ND	8.83E-10	ND	1.2E-09	NA
	Fluoranthene	1.50E-06	2.00E-02	ND	2.69E-11	ND	1.3E-09	NA
	INAeno(1,2,3-cd)pyrene	4.30E-09	ND	2.40E+00	4.06E-13	1.74E-13	NA	4.2E-13
	Methylene Chloride	1.18E-02	6.00E-02	1.40E-02	2.64E-09	1.13E-09	4.4E-08	1.6E-11
	Phenanthrene	4.30E-06	1.50E-01	ND	5.77E-11	ND	3.8E-10	NA
	Pyrene	2.10E-06	1.50E-02	ND	5.53E-11	ND	3.7E-09	NA
	Tetrachloroethene	3.24E-03	9.00E-03	5.67E-02	7.73E-09	3.31E-09	8.6E-07	1.9E-10
	trans-1,2-Dichloroethene	3.37E-03	1.80E-02	ND	2.18E-09	ND	1.2E-07	NA
	Trichloroethene	6.63E-03	5.40E-03	1.67E-02	5.27E-09	2.26E-09	9.8E-07	3.8E-11
	SUM						**4.0E-06**	**4.1E-10**
Upgradient Perimeter Wells	1,2-dichloropropane	1.30E+01	ND	7.00E-02	ND	2.77E-06	NA	1.9E-07
	Carbon Tetrachloride	8.00E-01	6.30E-04	1.67E-01	8.75E-07	3.75E-07	1.4E-03	6.3E-08
	Di-n-butyl phthalate	2.00E+00	8.50E-02	ND	1.89E-05	8.10E-06	2.2E-04	NA
	Diethylphthalate	2.00E+00	7.20E-01	ND	4.77E-07	2.05E-07	6.6E-07	NA
	Trichloroethene	5.20E+02	5.40E-03	1.67E-02	4.14E-04	1.77E-04	7.7E-02	3.0E-06
	SUM						**7.8E-02**	**3.2E-06**
Downgradient Perimeter Wells	1,2-Dichloropropane	4.10E+00	ND	7.00E-02	ND	8.74E-07	NA	6.1E-08
	bis(2-ethylhexyl)phthalate	7.00E+00	1.80E-02	9.33E-03	1.60E-05	6.86E-06	8.9E-04	6.4E-08
	Chrysene	6.00E+00	ND	2.40E-01	ND	1.04E-04	NA	2.5E-05
	cis-1,2-dichloroethene	1.30E+01	9.00E-03	ND	9.70E-07	ND	1.1E-04	NA
	Tetrachloroethene	1.10E+02	9.00E-03	5.67E-02	2.63E-04	1.13E-04	2.9E-02	6.4E-06
	Trichloroethene	4.10E+01	5.40E-03	1.67E-02	3.26E-05	1.40E-05	6.0E-03	2.3E-07
	SUM						**3.6E-02**	**3.2E-05**

ND - No data
NA - Not applicable

Table J-5-3

Potential Risks for Adult RME Residential Exposure Scenario
Inhalation of VOCs
California Air National Guard - Fresno, California

Site or Location	Chemical	Indoor Air Concentration (mg/m3)	Noncarcinogenic Intake (mg/kg-day)	Carcinogenic Intake (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation Cancer Slope Factor (1/[mg/kg-day])	Hazard Index	Incremental Lifetime Cancer Risk
Site 5 - Measured Concentrations	Tetrachloroethene	1.30E-02	2.67E-03	1.14E-03	1.0E-02	2.1E-02	2.7E-01	2.4E-05
	Trichloroethene	9.50E-03	1.95E-03	8.37E-04	6.0E-03	1.0E-02	3.3E-01	8.4E-06
	SUM						**5.9E-01**	**3.2E-05**
Site 5 - Modeled Concentrations	Acetone	1.15E-03	2.36E-04	1.01E-04	1.00E-01	ND	2.4E-03	NA
	Benzo(a)pyrene	ND	ND	ND	ND	3.9E+00	NA	NA
	Benzo(b)fluoranthene	ND	ND	ND	ND	3.9E-01	NA	NA
	Benzo(k)fluoranthene	ND	ND	ND	ND	3.9E-01	NA	NA
	bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	8.4E-03	NA	NA
	Chrysene	ND	ND	ND	ND	3.9E-02	NA	NA
	cis-1,2-Dichloroethene	1.73E-06	3.55E-07	1.52E-07	1.00E-02	ND	3.6E-05	NA
	Diethylphthalate	ND	ND	ND	ND	ND	NA	NA
	Fluoranthene	ND	ND	ND	ND	ND	NA	NA
	INAeno(1,2,3-cd)pyrene	ND	ND	ND	ND	3.9E-01	NA	NA
	Methylene Chloride	5.90E-06	1.21E-06	5.20E-07	8.60E-01	3.5E-03	1.4E-06	1.8E-09
	Phenanthrene	ND	ND	ND	ND	ND	NA	NA
	Pyrene	ND	ND	ND	ND	ND	NA	NA
	Tetrachloroethene	1.62E-06	3.33E-07	1.43E-07	1.00E-02	2.1E-02	3.3E-05	3.0E-09
	trans-1,2-Dichloroethene	1.69E-06	3.46E-07	1.48E-07	2.00E-02	ND	1.7E-05	ND
	Trichloroethene	3.32E-06	6.81E-07	2.92E-07	6.00E-03	1.0E-02	1.1E-04	2.9E-09
	SUM						**2.6E-03**	**7.7E-09**
Upgradient Perimeter Wells	1,2-dichloropropane	6.50E-03	1.34E-03	5.72E-04	1.10E-03	6.3E-02	1.2E+00	3.6E-05
	Carbon Tetrachloride	4.00E-04	8.22E-05	3.52E-05	5.70E-04	1.5E-01	1.4E-01	5.3E-06
	Di-n-butyl phthalate	ND	ND	ND	ND	ND	NA	NA
	Diethylphthalate	ND	ND	ND	ND	ND	NA	NA
	Trichloroethene	2.60E-01	5.34E-02	2.29E-02	6.00E-03	1.0E-02	8.9E+00	2.3E-04
	SUM						**1.0E+01**	**2.7E-04**
Downgradient Perimeter Wells	1,2-Dichloropropane	2.05E-03	4.21E-04	1.81E-04	1.1E-03	6.3E-02	3.8E-01	1.1E-05
	bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	8.4E-03	NA	NA
	Chrysene	ND	ND	ND	ND	3.9E-02	NA	NA
	cis-1,2-dichloroethene	6.50E-03	1.34E-03	5.72E-04	1.0E-02	ND	1.3E-01	NA
	Tetrachloroethene	5.50E-02	1.13E-02	4.84E-03	1.0E-02	2.1E-02	1.1E+00	1.0E-04
	Trichloroethene	2.05E-02	4.21E-03	1.81E-03	6.0E-03	1.0E-02	7.0E-01	1.8E-05
	SUM						**2.3E+00**	**1.3E-04**

D - No data
A - Not applicable

Table J-5-4

Potential Risks for Adult RME Residential Exposure Scenario
Ingestion of Groundwater
California Air National Guard - Fresno, California

Site or Location	Chemical	Groundwater Concentration (ug/L)	Noncarcinogenic Intake (mg/kg-day)	Carcinogenic Intake (mg/kg-day)	Oral RfD (mg/kg-day)	Oral Cancer Slope Factor (1/[mg/kg-day])	Hazard Index	Incremental Lifetime Cancer Risk
Site 5 - Measured Concentrations	Tetrachloroethene	2.60E+01	7.12E-04	3.05E-04	1.00E-02	5.10E-02	7.1E-02	1.6E-05
	Trichloroethene	1.90E+01	5.21E-04	2.23E-04	6.00E-03	1.50E-02	8.7E-02	3.3E-06
	SUM						**1.6E-01**	**1.9E-05**
Site 5 - Modeled Concentrations	Acetone	2.30E+00	6.30E-05	2.70E-05	1.00E-01	ND	6.3E-04	NA
	Benzo(a)pyrene	2.50E-07	6.85E-12	2.94E-12	ND	1.20E+01	NA	3.5E-11
	Benzo(b)fluoranthene	8.40E-08	2.30E-12	9.86E-13	ND	1.20E+00	NA	1.2E-12
	Benzo(k)fluoranthene	4.50E-08	1.23E-12	5.28E-13	ND	1.20E+00	NA	6.3E-13
	bis(2-ethylhexyl)phthalate	7.47E-05	2.05E-09	8.77E-10	2.00E-02	8.40E-03	1.0E-07	7.4E-12
	Chrysene	6.70E-07	1.84E-11	7.87E-12	ND	1.20E-01	NA	9.4E-13
	cis-1,2-Dichloroethene	3.46E-03	9.48E-08	4.06E-08	1.00E-02	ND	9.5E-06	NA
	Diethylphthalate	3.70E-03	1.01E-07	4.34E-08	8.00E-01	ND	1.3E-07	NA
	Fluoranthene	1.50E-06	4.11E-11	1.76E-11	4.00E-02	ND	1.0E-09	NA
	INAeno(1,2,3-cd)pyrene	4.30E-09	1.18E-13	5.05E-14	ND	1.20E+00	NA	6.1E-14
	Methylene Chloride	1.18E-02	3.23E-07	1.39E-07	6.00E-02	1.40E-02	5.4E-06	1.9E-09
	Phenanthrene	4.30E-06	1.18E-10	5.05E-11	3.00E-01	ND	3.9E-10	NA
	Pyrene	2.10E-06	5.75E-11	2.47E-11	3.00E-02	ND	1.9E-09	NA
	Tetrachloroethene	3.24E-03	8.88E-08	3.80E-08	1.00E-02	5.10E-02	8.9E-06	1.9E-09
	trans-1,2-Dichloroethene	3.37E-03	9.23E-08	3.96E-08	2.00E-02	ND	4.6E-06	NA
	Trichloroethene	6.63E-03	1.82E-07	7.78E-08	6.00E-03	1.50E-02	3.0E-05	1.2E-09
	SUM						**6.9E-04**	**5.1E-09**
Upgradient Perimeter Wells	1,2-dichloropropane	1.30E+01	3.56E-04	1.53E-04	ND	6.30E-02	NA	9.6E-06
	Carbon Tetrachloride	8.00E-01	2.19E-05	9.39E-06	7.00E-04	1.50E-01	3.1E-02	1.4E-06
	Di-n-butyl phthalate	2.00E+00	5.48E-05	2.35E-05	1.00E-01	ND	5.5E-04	NA
	Diethylphthalate	2.00E+00	5.48E-05	2.35E-05	8.00E-01	1.50E-02	6.8E-05	NA
	Trichloroethene	5.20E+02	1.42E-02	6.11E-03	6.00E-03	1.50E-02	2.4E+00	9.2E-05
	SUM					**7.8E-02**	**2.4E+00**	**1.0E-04**
Downgradient Perimeter Wells	1,2-Dichloropropane	4.10E+00	1.12E-04	4.81E-05	ND	6.30E-02	NA	3.0E-06
	bis(2-ethylhexyl)phthalate	7.00E+00	1.92E-04	8.22E-05	2.00E-02	8.40E-03	9.6E-03	6.9E-07
	Chrysene	6.00E+00	1.64E-04	7.05E-05	ND	1.20E-01	NA	8.5E-06
	cis-1,2-dichloroethene	1.30E+01	3.56E-04	1.53E-04	1.00E-02	ND	3.6E-02	NA
	Tetrachloroethene	1.10E+02	3.01E-03	1.29E-03	1.00E-02	5.10E-02	3.0E-01	6.6E-05
	Trichloroethene	4.10E+01	1.12E-03	4.81E-04	6.00E-03	1.50E-02	1.9E-01	7.2E-06
	SUM					**3.6E-02**	**5.3E-01**	**8.5E-05**

ND - No data
NA - Not applicable

Table J-5-5

Summary of Potential Risks for Adult RME Residential Exposure Scenario
California Air National Guard - Fresno, California

Site or Location	Chemical	HAZARD INDEX Dermal (mg/kg-day)	HAZARD INDEX Oral (mg/kg-day)	HAZARD INDEX Inhalation (mg/kg-day)	TOTAL HAZARD INDEX	INCREMENTAL LIFETIME CANCER RISK Dermal (mg/kg-day)	INCREMENTAL LIFETIME CANCER RISK Oral (mg/kg-day)	INCREMENTAL LIFETIME CANCER RISK Inhalation (mg/kg-day)	TOTAL INCREMENTAL LIFETIME CANCER RISK
Site 5 - Measured Concentrations	Tetrachloroethene	6.9E-03	7.1E-02	2.7E-01	3.5E-01	1.5E-06	1.6E-05	2.4E-05	4.1E-05
	Trichloroethene	2.8E-03	8.7E-02	3.3E-01	4.1E-01	1.1E-07	3.3E-06	8.4E-06	1.2E-05
	SUM	**9.7E-03**	**1.6E-01**	**5.9E-01**	**7.6E-01**	**1.6E-06**	**1.9E-05**	**3.2E-05**	**5.3E-05**
Site 5 - Modeled Concentrations	Acetone	1.9E-06	6.3E-04	2.4E-03	3.0E-03	NA	NA	NA	NA
	Benzo(a)pyrene	NA	NA	NA	NA	1.5E-10	3.5E-11	NA	1.9E-10
	Benzo(b)fluoranthene	NA	NA	NA	NA	5.2E-12	1.2E-12	NA	6.3E-12
	Benzo(k)fluoranthene	NA	NA	NA	NA	9.2E-12	6.3E-13	NA	9.8E-12
	bis(2-ethylhexyl)phthalate	9.5E-09	1.0E-07	NA	1.1E-07	6.8E-13	7.4E-12	NA	8.1E-12
	Chrysene	NA	NA	NA	NA	2.8E-12	9.4E-13	NA	3.7E-12
	cis-1,2-Dichloroethene	2.9E-08	9.5E-06	3.6E-05	4.5E-05	NA	NA	NA	NA
	Diethylphthalate	1.2E-09	1.3E-07	NA	1.3E-07	NA	NA	NA	NA
	Fluoranthene	1.3E-09	1.0E-09	NA	2.4E-09	NA	NA	NA	NA
	Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	4.2E-13	6.1E-14	NA	4.8E-13
	Methylene Chloride	4.4E-08	5.4E-06	1.4E-06	6.8E-06	1.6E-11	1.9E-09	1.8E-09	3.8E-09
	Phenanthrene	3.8E-10	3.9E-10	NA	7.8E-10	NA	NA	NA	NA
	Pyrene	3.7E-09	1.9E-09	NA	5.6E-09	NA	NA	NA	NA
	Tetrachloroethene	8.6E-07	8.9E-06	3.3E-05	4.3E-05	1.9E-10	1.9E-09	3.0E-09	5.1E-09
	trans-1,2-Dichloroethene	1.2E-07	4.6E-06	1.7E-05	2.2E-05	NA	NA	NA	NA
	Trichloroethene	9.8E-07	3.0E-05	1.1E-04	1.4E-04	3.8E-11	1.2E-09	2.9E-09	4.1E-09
	SUM	**4.0E-06**	**6.9E-04**	**2.6E-03**	**3.3E-03**	**4.1E-10**	**5.1E-09**	**7.7E-09**	**1.3E-08**
Upgradient Perimeter Wells	1,2-dichloropropane	NA	NA	1.2E+00	1.2E+00	1.9E-07	9.6E-06	3.6E-05	4.6E-05
	Carbon Tetrachloride	1.4E-03	3.1E-02	1.4E-01	1.8E-01	6.3E-08	1.4E-06	5.3E-06	6.8E-06
	Di-n-butyl phthalate	2.2E-04	5.5E-04	NA	7.7E-04	NA	NA	NA	NA
	Diethylphthalate	6.6E-07	6.8E-05	NA	6.9E-05	NA	NA	NA	NA
	Trichloroethene	7.7E-02	2.4E+00	8.9E+00	1.1E+01	3.0E-06	9.2E-05	2.3E-04	3.2E-04
	SUM	**7.8E-02**	**2.4E+00**	**1.0E+01**	**1.3E+01**	**3.2E-06**	**1.0E-04**	**2.7E-04**	**3.8E-04**
Downgradient Perimeter Wells	1,2-Dichloropropane	NA	NA	3.8E-01	3.8E-01	6.1E-08	3.0E-06	1.1E-05	1.4E-05
	bis(2-ethylhexyl)phthalate	8.9E-04	9.6E-03	NA	1.0E-02	6.4E-08	6.9E-07	NA	7.5E-07
	Chrysene	NA	NA	NA	NA	2.5E-05	8.5E-06	NA	3.3E-05
	cis-1,2-dichloroethene	1.1E-04	3.6E-02	1.3E-01	1.7E-01	NA	NA	NA	NA
	Tetrachloroethene	2.9E-02	3.0E-01	1.1E+00	1.5E+00	6.4E-06	6.6E-05	1.0E-04	1.7E-04
	Trichloroethene	6.0E-03	1.9E-01	7.0E-01	9.0E-01	2.3E-07	7.2E-06	1.8E-05	2.6E-05
	SUM	**3.6E-02**	**5.3E-01**	**2.3E+00**	**2.9E+00**	**3.2E-05**	**8.5E-05**	**1.3E-04**	**2.5E-04**

NA [illegible] applicable

Table J-5-6

Summary of Potential Risks for Child RME Residential Exposure Scenario
California Air National Guard - Fresno, California

Site or Location	Chemical	Indoor Air Concentration (mg/m3)	Noncarcinogenic Intake Dermal (mg/kg-day)	Noncarcinogenic Intake Oral (mg/kg-day)	Noncarcinogenic Intake Inhalation (mg/kg-day)	Reference Doses Dermal RfD (mg/kg-day)	Reference Doses Oral RfD (mg/kg-day)	Reference Doses Inhalation RfD (mg/kg-day)	Hazard Index Dermal (mg/kg-day)	Hazard Index Oral (mg/kg-day)	Hazard Index Inhalation (mg/kg-day)	TOTAL HAZARD INDEX
Site 5 - Measured Concentrations	Tetrachloroethene	1.30E-02	8.04E-05	1.66E-03	1.66E-03	9.00E-03	1.00E-02	1.42E-04	8.9E-03	1.7E-01	1.7E-01	3.41E-01
	Trichloroethene	9.50E-03	1.96E-05	1.21E-03	1.21E-03	5.40E-03	6.00E-03	1.04E-04	3.6E-03	2.0E-01	2.0E-01	4.08E-01
	SUM								1.3E-02	3.7E-01	**3.7E-01**	**7.50E-01**
Site 5 - Modelled Concentrations	Acetone	1.15E-03	5.69E-08	4.03E-05	4.03E-05	8.30E-02	1.00E-01	3.45E-06	6.9E-07	4.0E-04	4.0E-04	8.07E-04
	Benzo(a)pyrene	ND	5.35E-12	4.43E-12	4.43E-12	ND	ND	3.79E-13	ND	ND	ND	NA
	Benzo(b)fluoranthene	ND	1.79E-12	1.48E-12	1.48E-12	ND	ND	1.27E-13	ND	ND	ND	NA
	Benzo(k)fluoranthene	ND	3.20E-12	7.94E-13	7.94E-13	ND	ND	6.80E-14	ND	ND	ND	NA
	bis(2-ethylhexyl)phthalate	ND	6.08E-11	1.31E-09	1.31E-09	1.80E-02	2.00E-02	1.12E-10	3.4E-09	6.6E-08	ND	6.89E-08
	Chrysene	ND	9.47E-12	1.16E-11	1.16E-11	ND	ND	9.94E-13	ND	ND	ND	NA
	cis-1,2-Dichloroethene	1.73E-06	9.14E-11	6.04E-08	6.04E-08	9.00E-03	1.00E-02	5.18E-09	1.0E-08	6.0E-06	6.0E-06	1.21E-05
	Diethylphthalate	ND	3.14E-10	6.49E-08	6.49E-08	7.20E-01	8.00E-01	5.56E-09	4.4E-10	8.1E-08	ND	8.16E-08
	Fluoranthene	ND	9.32E-12	2.57E-11	2.57E-11	2.00E-02	4.00E-02	2.20E-12	4.7E-10	6.4E-10	ND	1.11E-09
	INAeno(1,2,3-cd)pyrene	ND	1.46E-13	7.60E-14	7.60E-14	ND	ND	6.52E-15	ND	ND	ND	NA
	Methylene Chloride	5.90E-06	9.11E-10	2.01E-07	2.01E-07	6.00E-02	6.00E-02	1.72E-08	1.5E-08	3.3E-06	2.3E-07	3.60E-06
	Phenanthrene	ND	2.07E-11	7.62E-11	7.62E-11	1.50E-01	3.00E-01	6.53E-12	1.4E-10	2.5E-10	ND	3.92E-10
	Pyrene	ND	1.95E-11	3.64E-11	3.64E-11	1.50E-02	3.00E-02	3.12E-12	1.3E-09	1.2E-09	ND	2.51E-09
	Tetrachloroethene	1.62E-06	2.75E-09	5.68E-08	5.68E-08	9.00E-03	1.00E-02	4.87E-09	3.1E-07	5.7E-06	5.7E-06	1.17E-05
	trans-1,2-Dichloroethene	1.69E-06	7.61E-10	5.81E-08	5.81E-08	1.80E-02	2.00E-02	4.98E-09	4.2E-08	2.9E-06	2.9E-06	5.85E-06
	Trichloroethene	3.32E-06	1.86E-09	1.16E-07	1.16E-07	5.40E-03	6.00E-03	9.90E-09	3.5E-07	1.9E-05	1.9E-05	3.89E-05
	SUM								1.4E-06	4.4E-04	4.4E-04	**8.79E-04**
Upgradient Perimeter Wells	1,2-dichloropropane	6.50E-03	8.38E-06	8.31E-04	8.31E-04	ND	ND	7.12E-05	ND	ND	7.6E-01	7.56E-01
	Carbon Tetrachloride	4.00E-04	1.13E-06	5.11E-05	5.11E-05	6.30E-04	7.00E-04	4.38E-06	1.8E-03	7.3E-02	9.0E-02	1.65E-01
	Di-n-butyl phthalate	ND	2.45E-05	1.28E-04	1.28E-04	8.50E-02	1.00E-01	1.10E-05	2.9E-04	1.3E-03	ND	1.57E-03
	Diethylphthalate	ND	6.19E-07	1.28E-04	1.28E-04	7.20E-01	8.00E-01	1.10E-05	8.6E-07	1.6E-04	ND	1.61E-04
	Trichloroethene	2.60E-01	5.36E-04	3.32E-02	3.32E-02	5.40E-03	6.00E-03	2.85E-03	9.9E-02	5.5E+00	5.5E+00	1.12E+01
	SUM								1.0E-01	5.6E+00	6.4E+00	**1.21E+01**
Downgradient Perimeter Wells	1,2-Dichloropropane	2.05E-03	2.64E-06	2.62E-04	2.62E-04	ND	ND	2.25E-05	ND	ND	2.4E-01	2.38E-01
	bis(2-ethylhexyl)phthalate	ND	2.07E-05	4.47E-04	4.47E-04	1.80E-02	2.00E-02	3.84E-05	1.2E-03	2.2E-02	ND	2.35E-02
	Chrysene	ND	3.13E-04	3.84E-04	3.84E-04	ND	ND	3.29E-05	ND	ND	ND	NA
	cis-1,2-dichloroethene	6.50E-03	1.26E-06	8.31E-04	8.31E-04	9.00E-03	1.00E-02	7.12E-05	1.4E-04	8.3E-02	8.3E-02	1.66E-01
	Tetrachloroethene	5.50E-02	3.40E-04	7.03E-03	7.03E-03	9.00E-03	1.00E-02	6.03E-04	3.8E-02	7.0E-01	7.0E-01	1.44E+00
	Trichloroethene	2.05E-02	4.23E-05	2.62E-03	2.62E-03	5.40E-03	6.00E-03	2.25E-04	7.8E-03	4.4E-01	4.4E-01	8.81E-01
	SUM								4.7E-02	1.2E+00	1.5E+00	**2.76E+00**

ND - No data
NA - Not applicable

Table J-5-7

Potential Risks for Adult Central Tendency Residential Exposure Scenario for Upgradient and Downgradient Monitoring Wells - Dermal Exposure California Air National Guard - Fresno, California

Site or Location	Chemical	Groundwater Concentration (ug/L)	Noncarcinogenic Intake (mg/kg-day)	Carcinogenic Intake (mg/kg-day)	Dermal RfD (mg/kg-day)	Dermal Cancer Slope Factor	Hazard Index	Incremental Lifetime Cancer Risk
Upgradient Perimeter Wells	1,2-dichloropropane	1.30E+01	3.88E-06	4.99E-07	ND	7.00E-02	NA	3.5E-08
	Carbon Tetrachloride	8.00E-01	5.25E-07	6.75E-08	6.30E-04	1.67E-01	1.4E-03	1.1E-08
	Di-n-butyl phthalate	2.00E+00	1.13E-05	1.46E-06	8.50E-02	ND	2.2E-04	NA
	Diethylphthalate	2.00E+00	2.86E-07	3.68E-08	7.20E-01	ND	6.6E-07	NA
	Trichloroethene	5.20E+02	2.48E-04	3.19E-05	5.40E-03	1.67E-02	7.7E-02	5.3E-07
	SUM						**7.8E-02**	**5.8E-07**
Downgradient Perimeter Wells	1,2-Dichloropropane	4.10E+00	1.22E-06	1.57E-07	ND	7.00E-02	NA	1.1E-08
	bis(2-ethylhexyl)phthalate	7.00E+00	9.61E-06	1.24E-06	1.80E-02	9.33E-03	8.9E-04	1.2E-08
	Chrysene	6.00E+00	1.45E-04	1.86E-05	ND	2.40E-01	NA	4.5E-06
	cis-1,2-dichloroethene	1.30E+01	5.82E-07	7.48E-08	9.00E-03	ND	1.1E-04	NA
	Tetrachloroethene	1.10E+02	1.58E-04	2.03E-05	9.00E-03	5.67E-02	2.9E-02	1.1E-06
	Trichloroethene	4.10E+01	1.96E-05	2.52E-06	5.40E-03	1.67E-02	6.0E-03	4.2E-08
	SUM						**3.6E-02**	**5.7E-06**

ND - No data
NA - Not applicable

Table J-5-8

Potential Risks for Adult Central Tendency Residential Exposure Scenario for Upgradient and Downgradient Monitoring Wells
Ingestion of Groundwater
California Air National Guard - Fresno, California

Site or Location	Chemical	Groundwater Concentration (µg/L)	Noncarcinogenic Intake (mg/kg-day)	Carcinogenic Intake (mg/kg-day)	Oral RfD (mg/kg-day)	Oral Cancer Slope Factor (1/[mg/kg-day])	Hazard Index	Incremental Lifetime Cancer Risk
Upgradient Perimeter Wells	1,2-dichloropropane	1.30E+01	2.67E-04	3.43E-05	ND	6.3E-02	NA	2.2E-06
	Carbon Tetrachloride	8.00E-01	1.64E-05	2.11E-06	7.00E-04	1.5E-01	2.3E-02	3.2E-07
	Di-n-butyl phthalate	2.00E+00	4.11E-05	5.28E-06	1.00E-01	ND	4.1E-04	NA
	Diethylphthalate	2.00E+00	4.11E-05	5.28E-06	8.00E-01	ND	5.1E-05	NA
	Trichloroethene	5.20E+02	1.07E-02	1.37E-03	6.00E-03	1.5E-02	1.8E+00	2.1E-05
	SUM						**1.8E+00**	**2.3E-05**
Downgradient Perimeter Wells	1,2-Dichloropropane	4.10E+00	8.42E-05	1.08E-05	ND	6.3E-02	NA	6.8E-07
	bis(2-ethylhexyl)phthalate	7.00E+00	1.44E-04	1.85E-05	2.00E-02	8.4E-03	7.2E-03	1.6E-07
	Chrysene	6.00E+00	1.23E-04	1.59E-05	ND	1.2E-01	NA	1.9E-06
	cis-1,2-dichloroethene	1.30E+01	2.67E-04	3.43E-05	1.00E-02	ND	2.7E-02	NA
	Tetrachloroethene	1.10E+02	2.26E-03	2.91E-04	1.00E-02	5.1E-02	2.3E-01	1.5E-05
	Trichloroethene	4.10E+01	8.42E-04	1.08E-04	6.00E-03	1.5E-02	1.4E-01	1.6E-06
	SUM						**4.0E-01**	**1.9E-05**

ND - No data
NA - Not applicable

Table J-5-9

Potential Risks for Adult Central Tendency Residential Exposure Scenario for Upgradient and Downgradient Monitoring Wells
Inhalation of VOCs
California Air National Guard - Fresno, California

Site or Location	Chemical	Indoor Air Concentration (mg/m3)	Noncarcinogenic Intake (mg/kg-day)	Carcinogenic Intake (mg/kg-day)	Inhalation RfD (mg/kg-day)	Inhalation Cancer Slope Factor (1/[mg/kg-day])	Hazard Index	Incremental Lifetime Cancer Risk
Upgradient Perimeter Wells	1,2-dichloropropane	6.50E-03	9.13E-04	1.17E-04	1.1E-03	6.3E-02	8.3E-01	7.4E-06
	Carbon Tetrachloride	4.00E-04	5.62E-05	7.22E-06	5.7E-04	1.5E-01	9.9E-02	1.1E-06
	Di-n-butyl phthalate	ND	ND	ND	ND	ND	NA	NA
	Diethylphthalate	ND	ND	ND	ND	ND	NA	NA
	Trichloroethene	2.60E-01	3.65E-02	4.69E-03	6.0E-03	1.0E-02	6.1E+00	4.7E-05
	SUM						**7.0E+00**	**5.5E-05**
Downgradient Perimeter Wells	1,2-Dichloropropane	2.05E-03	2.88E-04	3.70E-05	1.1E-03	6.3E-02	2.6E-01	2.3E-06
	bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	8.4E-03	NA	NA
	Chrysene	ND	ND	ND	ND	ND	NA	NA
	cis-1,2-dichloroethene	6.50E-03	9.13E-04	1.17E-04	1.0E-02	ND	9.1E-02	NA
	Tetrachloroethene	5.50E-02	7.72E-03	9.93E-04	1.0E-02	2.1E-02	7.7E-01	2.1E-05
	Trichloroethene	2.05E-02	2.88E-03	3.70E-04	6.0E-03	1.0E-02	4.8E-01	3.7E-06
	SUM						**1.6E+00**	**2.7E-05**

ND - No data
NA - Not applicable

Table J-5-10

Summary of Potential Risks for Adult Central Tendency Residential Exposure Scenario for Upgradient and Downgradient Monitoring Wells
California Air National Guard - Fresno, California

Site or Location	Chemical	HAZARD INDEX Dermal (mg/kg-day)	HAZARD INDEX Oral (mg/kg-day)	HAZARD INDEX Inhalation (mg/kg-day)	TOTAL HAZARD INDEX	INCREMENTAL LIFETIME CANCER RISK Dermal (mg/kg-day)	INCREMENTAL LIFETIME CANCER RISK Oral (mg/kg-day)	INCREMENTAL LIFETIME CANCER RISK Inhalation (mg/kg-day)	TOTAL INCREMENTAL LIFETIME CANCER RISK
Upgradient Perimeter Wells	1,2-dichloropropane	NA	NA	8.3E-01	8.3E-01	3.5E-08	2.2E-06	7.4E-06	9.6E-06
	Carbon Tetrachloride	8.3E-04	2.3E-02	9.9E-02	1.2E-01	1.1E-08	3.2E-07	1.1E-06	1.4E-06
	Di-n-butyl phthalate	1.3E-04	4.1E-04	NA	5.4E-04	NA	NA	NA	NA
	Diethylphthalate	4.0E-07	5.1E-05	NA	5.2E-05	NA	NA	NA	NA
	Trichloroethene	4.6E-02	1.8E+00	6.1E+00	7.9E+00	5.3E-07	2.1E-05	4.7E-05	6.8E-05
	SUM	**4.7E-02**	**1.8E+00**	**7.0E+00**	**8.9E+00**	**5.8E-07**	**2.3E-05**	**5.5E-05**	**7.9E-05**
Downgradient Perimeter Wells	1,2-Dichloropropane	NA	NA	2.6E-01	2.6E-01	1.1E-08	6.8E-07	2.3E-06	3.0E-06
	bis(2-ethylhexyl)phthalate	5.3E-04	7.2E-03	NA	7.7E-03	1.2E-08	1.6E-07	NA	1.7E-07
	Chrysene	NA	NA	NA	0.0E+00	4.5E-06	1.9E-06	NA	6.4E-06
	cis-1,2-dichloroethene	6.5E-05	2.7E-02	9.1E-02	1.2E-01	NA	NA	NA	NA
	Tetrachloroethene	1.8E-02	2.3E-01	7.7E-01	1.0E+00	1.1E-06	1.5E-05	2.1E-05	3.7E-05
	Trichloroethene	3.6E-03	1.4E-01	4.8E-01	6.2E-01	4.2E-08	1.6E-06	3.7E-06	5.4E-06
	SUM	**2.2E-02**	**4.0E-01**	**1.6E+00**	**2.0E+00**	**5.7E-06**	**1.9E-05**	**2.7E-05**	**5.2E-05**

NA - Not applicable

Table J-8-1

Summary of Significant Adult RME Risk Results
California Air National Guard - Fresno, California

Groundwater: Measured Concentrations

Pathway	Upgradient Wells	Downgradient Wells
Cancer Risk		
Ingestion	TCE: 9.2×10^{-5} DCP: 9.6×10^{-6} CT: 1.4×10^{-6}	None
Dermal Contact	None	None
Inhalation of Volatiles	TCE: 2.3×10^{-4} PCP: 3.6×10^{-5} CT: 5.3×10^{-6}	PCE: 1.0×10^{-4} TCE: 1.8×10^{-5} DCP: 1.1×10^{-5}
Noncancer Risk		
Ingestion	TCE 2.4	None
Dermal Contact	None	None
Inhalation of Volatiles	TCE: 8.9 DCP 1.2	PCE: 1.1 TCE: 0.7

PCE = Tetrachloroethene
TCE = Trichloroethene
DCP = 1,2-Dichloropropane
CT = Carbon tetrachloride
CHRY = Chrysene

Table J-8-2

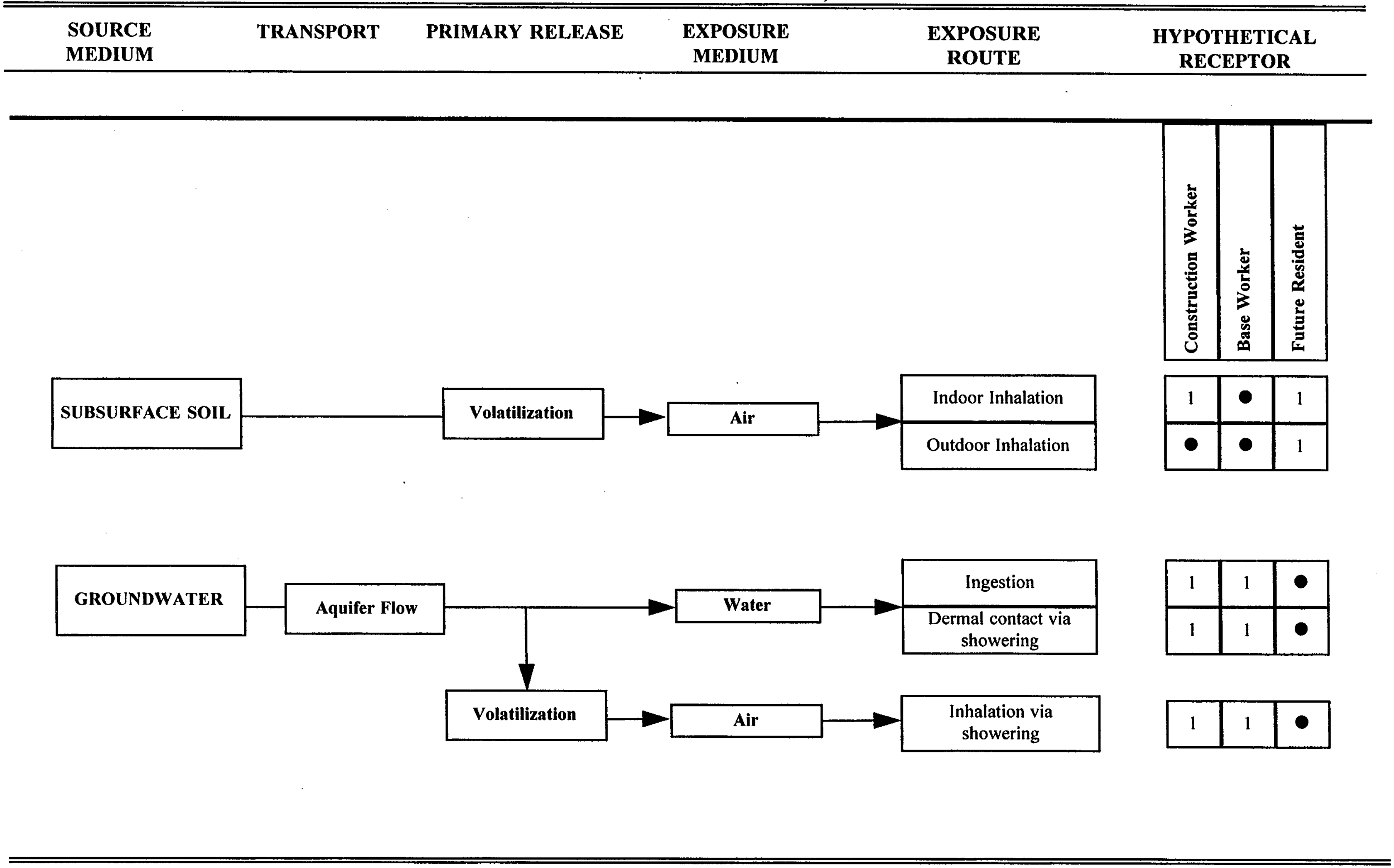
Summary of Significant Child RME Risk Results
California Air National Guard - Fresno, California

Groundwater: Measured Concentrations

Pathway	Upgradient Wells	Downgradient Wells
Cancer Risk		
Ingestion	None	None
Dermal Contact	None	None
Inhalation of Volatiles	None	None
Noncancer Risk		
Ingestion	TCE: 5.5	PCE: 0.7 TCE: 0.4
Dermal Contact	None	None
Inhalation of Volatiles	None	None

PCE = Tetrachloroethene
TCE = Trichloroethene

Figure J-3
Conceptual Site Exposure Model
California Air National Guard - Fresno, California



● = Potentially complete exposure pathway
1 = Incomplete exposure pathway